Mineral Resources of Kansas.

1897.

Gold and Silver.
Lead and Zinc.
Coal.
Oil and Gas.
Salt.
Gypsum.
Hydraulic Cement.
Building Stone.
Clay Goods.

THE

UNIVERSITY GEOLOGICAL SURVEY OF KANSAS.

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ON

MINERAL RESOURCES

OF

KANSAS,

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PREFACE.

FOR years the writer has had forced upon him in many different ways, and under many different circumstances, the fact that no publication has ever been made giving in a concise and precise form the output of the various mines and smelters of the state of Kansas. For many years hundreds of inquiries have been received from outside the state asking for printed matter relating to the mineral resources of Kansas. Similar letters of inquiry have been sent the writer by the Governor, the Secretary of State, and other state officials at Topeka, each one of whom was obliged to say in his explanatory letter: "I know of no such published documents; can you assist us?"

However, the inquiries from outside the state have been few in comparison with those from within. It would probably not be overstating the matter to say that we have few citizens in our whole state who are well informed on the mineral resources which we possess. Many have a vague idea that, somewhere in the southeast part of the state, lead ores and zinc ores are mined and smelted, and have expressed great surprise that, for a period of years, not a single lead smelter was in operation within our borders. Others have thought that our lead ores were shipped to the coal fields in the vicinity of Pittsburg and Weir City, on account of the cheapness of fuel in that vicinity; not knowing, first, that coal is seldom used in smelting lead ores, and second, that the amount of fuel used in such operations is so small that it is of comparatively little importance. Still others, with whom the writer has talked, have known of the extensive zinc smelting plants near our great coal mines, and have stoutly insisted that, of course, our zinc mining and zinc smelting industries are carried on in the same localities. A similar lack of exact information regarding other mining operations is constantly met with by our own citizens and by those outside our state.

Our state board of agriculture issues biennially a large volume, and lesser reports quarterly, which publish to the world the natural resources of Kansas in agriculture, stock-raising, and dairying. Our importance in those lines is thereby known and recognized all over the civilized world. This is in strong contrast with our reputation in mining and metallurgical operations. Few people realize that in zinc smelting we are second only to one other state; that in coal mining

we compare favorably with the states in the great Mississippi valley coal fields; that our lead and zinc mines, although confined to but a few square miles in area, produce annually almost as much as the whole of southwestern Missouri, which is generally recognized as a great lead and zinc mining locality; that our fields of natural gas and petroleum are attracting the attention of operators from all over the East, and that many large manufacturing establishments are now seeking locations within our state, attracted by the rich oil wells and numerous gas flows from many different places in the southeast part of the state; that our gypsum cement plasters are now shipped to all parts of the United States and are recognized as being equal in quality with those made anywhere in the world, commanding even a higher price than those from any other locality; and that our salt mines are sufficiently productive to supply nearly one-half the territory of the United States and to reduce the price of salt to the consumer to less than half what it was before the mines were opened.

It is with a hope of assisting to place these matters honestly and fairly before the world that the following annual report is issued.

In order to assist in determining the desirability of inaugurating an annual state report of this character, to be issued as a bulletin of the University Geological Survey of Kansas, the writer sent letters to a large number of the leading citizens of Kansas, representative men of varied occupations and interests, asking an honest opinion as to the advisability of issuing such a report. Without a single exception, every reply received urged that the work be undertaken.

Such an annual bulletin will, therefore, be made a feature of our University Geological Survey, with the expectation that it be continued for a number of years. A work of this kind can only be produced by the combined coöperation of all parties interested in the production of mineral wealth. The law requires the coal mine operators to make reports to our State Inspector of Coal Mines, but there is no law requiring other mine operators and smelter operators to make any report whatever to any one. It is exceedingly gratifying to the writer to be able to say that in most cases his inquiries have been responded to with a promptness and willingness which imply continued interest in the matter, and which bespeak a similar coöperation for future years. To all such parties, and to others who have assisted in this work, the writer wishes to express his sincere thanks.

ERASMUS HAWORTH.

UNIVERSITY OF KANSAS,
Lawrence, April 15, 1898.

INTRODUCTION.

IT is interesting to know the relative importance of America's great industries. Our industrial activities may, in a general way, be divided into three great classes: The production of raw materials, the manufacturing of raw materials into commodities, and the disposition of such commodities. These three great divisions may be named respectively, the department of production, the department of manufacturing, and the department of commerce.

It is with the former only that we are concerned at present. This may also be divided into three great divisions: The mineral industry, or mines and mining; the vegetable industry, or agriculture and horticulture proper; and the animal industry, or the production of meats and dairy and poultry products. Let us compare these three divisions of production, to determine the relative extent and importance of each.

Statistics are difficult matters to handle. It is a common saying that one can prove anything by statistics. Usually the great difficulty in understanding them lies in a lack of proper modes of comparison. Unlike matters should not be compared. Yet in many cases comparisons which are made and published to the world and used by every one are sources of great error on account of comparing unlike values.

Unfortunately our government officials and others, whose duty it might be made to gather statistics along these several lines, rarely do their work as might be desired. For example, the mining statistics show the actual production of materials for a year, entirely independent of the value of mining property and of mining, milling, and smelting plants. Our agricultural statistics likewise show the actual production for a year from the soil, entirely independent of the value of real estate and fixtures. But the same class of statistics gatherers in dealing with live stock pursue a different course. Our United States Department of Agriculture issues annually an estimate, not of the number of animals slaughtered for meats during the year, but of the number of animals on the farms at a given date for each year, introducing a factor which cannot be compared directly with the total annual production in other lines. The farmer who raises beef cattle, mutton sheep, and porkers has for his ultimate object the production of meats; and the dairyman who raises milch cows has for his ultimate object the production of milk, or of butter, or of cheese. The

number of animals which the meat producer may chance to have on hand January 1st is but little indication of the pounds of meat he has sold during the past year; nor is the number of cows the dairyman has on his farm January 1st an indication of the pounds of butter, or of milk, or of cheese he has produced in the past year. The stock cattle and dairy cattle correspond to the plant of the manufacturer, to the mines and mining machinery of the mine owner, and to the lands and the fixtures of the agriculturist. To make a comparison, therefore, of the mining products of America with the total production of agricultural products, or of dairy products, or of meat products, we should have statistics showing the total amount produced for each year, rather than the total number of animals at any particular date.

Our mining statistics are gathered with a high degree of accuracy by our United States Geological Survey, and by different private organizations, particularly the Engineering and Mining Journal Company, of New York, so that statistics on mining can be relied upon as possessing as high a degree of accuracy, perhaps, as any statistics of like nature gathered in America. Our dairy products likewise are estimated with a fair degree of accuracy, due largely to the highly perfected dairy organizations and the general interest in dairy matters resulting therefrom. But the meat products of America have little attention paid to them. Our United States Agricultural Department makes no attempt to estimate these products, and but few of the several state organizations give much attention to this subject. Fortunately our federal laws provide for governmental inspectors at all of the principal centers where live stock are slaughtered. These inspectors keep accurate records of the number of animals slaughtered at such points, so that we have reliable figures from these great centers; but nothing more than a mere approximation is available for estimating the number of animals slaughtered in the hundreds of lesser establishments, and by the farmers for private use all over America.

Another element of unfairness in comparing these three great lines of production lies in the fact that the animal ready for slaughter is to a great extent a manufactured product. If we add the value of the meat production to the value of the agricultural products we have a sum which in reality is too large unless a similar process were followed in estimating the mining products. For example, the farmer raises 1000 bushels of corn, which is estimated at twenty-five cents a bushel, giving \$250. He feeds this to steers and hogs, producing thereby meat having a value of \$500, giving a total of \$750, while in reality he receives only \$500 for his labor.

This calculation corresponds to an estimate of \$750 for \$250 worth

of Minnesota iron ore which is shipped to the smelter and changed into pig iron of a value of $500. Those gathering mineral statistics usually do not make their computations in this way. The reports of our United States Geological Survey, for example, use the total value of the pig iron in making their summaries, and not the value of the ores plus the value of the pig iron. Whether this is the better mode of procedure depends entirely upon the purpose for which the statistics are gathered. In order to compare the mining products with the agricultural products and the meat products such an error should be corrected, but at present it is impossible to do it. In the tables which follow both kinds of calculations have been made.

Again, in making estimates of the live stock it is difficult to know at all times what line of procedure to follow. Horses and mules have certain values. They are produced at certain costs. Their ultimate value depends upon the labor they perform, a matter which cannot be estimated. It is manifestly unfair to count the number of such animals in existence on January 1st of any year with a value of $50 per head, or whatever it may be, and use that for the annual production in comparison with the annual meat production or other similar matters. It requires from three to six years to produce a horse, and the product will give service of value for an indefinite number of years. It might, therefore, be proper to find the total value of horses and mules at a given date and divide that by a number representing the average life of such animals. If for every million of horses in existence the average life is six years, it would require the production of one-sixth of a million to maintain the number. Such a basis of estimation is used in the following tables.

Likewise, in estimating the dairy products for these comparisons, the calves dropped, and the yearlings, and the two-year olds too young for dairy purposes should not be considered, because they are nonproductive until the period of lactation is reached. All animals which are worthless for dairy purposes are sent to the shambles, and are therefore counted as meat producers.

For the purpose of obtaining a somewhat clear conception of the relative importance of the various lines of production of raw materials as above outlined, the tables printed on pages 10 and 11 have been prepared.

TABLE I.

SHOWING MINING PRODUCTION IN THE UNITED STATES DURING 1897.

Estimated by the "Engineering and Mining Journal."

Non-metallic	$504,609,934
Metallic	257,451,172
Total	$762,061,106

TABLE II.

SHOWING AGRICULTURAL PRODUCTS IN THE UNITED STATES DURING 1897.

From United States Department of Agriculture (except cotton).

Corn	$501,072,952
Wheat	428,547,121
Oats	147.974,719
Rye	12,239,647
Barley	25,142,139
Hay	401.390,728
Potatoes	89,643,059
Cotton (estimated)	193,989,635
Total	$1,800,000,000

TABLE III.

SHOWING MEAT PRODUCTION IN THE UNITED STATES DURING 1897.

Item.	Number animals slaughtered.	Price per head.	Value.
128 Abattoirs … 33 Cities … Beeves	8,254,000	$46 00	$379,684,000
Hogs	25,550,000	9 00	229,950,000
Sheep	8,030.000	4 00	32.120,000
Calves	445,000	10 00	4,450,000
Estimated slaughter at small towns and for rural consumption			103,796,000
Total			$750,000,000

TABLE IV.

SHOWING DAIRY PRODUCTION IN THE UNITED STATES DURING 1897.

Based upon the census of 1895.

Item.	Number.	Production.	Value of product.
Cows milked for butter	11,000,000	1,400.000,000 lbs.	$280.000,000
Cows milked for cheese	1,000,000	300,000,000 lbs.	24,000,000
Cows milked for milk	5,000,000	1,800,000,000 gals.	162.000,000
Estimated increase since 1895,			34,000,000
Total			$500,000,000

TABLE V.

SHOWING SUMMARY OF ABOVE, WITH ADDITION OF POULTRY, WOOL, AND HORSES AND MULES, WITH PER CENT. OF EACH.

Item.		Value.	Per cent. of whole product.	
Mining product		$760,000,000	17.62	17.62
Agriculture		1,800,000,000	41.74	41.74
Animal products.	Meat product	750,000,000	17.40	
	Dairy product	500,000,000	11.59	
	Poultry product	350,000,000	8.12	40.64
	Horses and mules	90,000,000	2.09	
	Wool clip	62,000,000	1.44	
Total		$4,312,000,000	100.00	100.00

What proportion of this four billion dollars did Kansas produce; what proportion of the several different items included within it; and, finally, what are the relative proportions of the various items going to constitute the total production of Kansas for 1897 are interesting questions. To answer them the following summaries are presented, gathered from more detailed tables presented later in this report.

TABLE VI.

SUMMARY OF THE VARIOUS KANSAS PRODUCTS.

Showing value of each, per cent. of corresponding United States product, and per cent. of total Kansas product.

Product.		Value of product.	Per cent. of corresponding U. S. product.		Per cent. of total Kansas product.	
Mining and smelting		$26,990,544	....	3.551	....	16.09
(Mining)		(9,157,792)	(1.201)	....	(5.47)	
Agriculture		89,351,336	....	4.963	....	53.27
Animal products.	Meats	37,781,678	5.037		22.53	
	Dairy products	5,259,752	1.052		3.14	
	Poultry products	3,850,997	1.100		2.30	
	Horses and mules	4,390,127	4.878	2.932	2.62	30.64
	Wool clip	91,495	.148		.05	
	Total animal value,	$51,374,049				
Totals		$167,715,831	....	3.8199	....	100.00

It will be seen from table VI that the total production of Kansas during 1897 reached nearly 168 million dollars, a fraction over three per cent. of the total production of the United States. Of these 168 millions, the mining and smelting interests amounted to nearly twenty-seven millions, or sixteen and a fraction per cent.; the agricultural products to a little over eighty-nine millions, or fifty-three and a fraction per cent.; and the animal products to fifty-one millions, or a little more than thirty per cent.

By a comparison of tables v and vi, it is found that our mining products — $9,157,792 — compared with the total of the Kansas products, are relatively below the mining products of the United States. But if we use the total value of our mining and smelting products, it raises the proportion almost to that of the United States, and higher than the total Kansas products are compared with the total United States production. Further, it will be seen that the Kansas agricultural products form a larger per cent. of the total Kansas products than the United States agricultural products do of the total national production, the former being 53.27 per cent. and the latter 41.74 per cent. But the animal products of Kansas constitute only 30.64 per cent. of the total Kansas production, while the animal products of the United States constitute 40.64 per cent. of the total production of the United States. It will be seen, therefore, by comparing the various products of Kansas with those of the United States, that our mining interests have about the same relative importance which our live-stock interests have.

The difficulty in obtaining a proper basis of comparison, before alluded to, is well illustrated in the mining statistics. Our lead ore and zinc ore mines of Galena during 1897 produced ore which had a marketable value at the mines of $2,255,133. This amount of money was obtained by the citizens of Galena and vicinity. Yet to compare the output of our mines with those of mines in other parts of the world, as comparisons are generally made, we should have a statement, not of the amount and value of the ore, but of the amount and value of the metals obtainable from the ores. The only possible way of arriving at such values is by calculation. Our zinc ores are shipped from Galena to at least three different states for smelting, and our lead ores are smelted in at least two different states. It is impossible to follow these ores to the various smelters, because they are thrown upon the general market at Galena.

For our purpose, therefore, the amount of metallic zinc obtainable from the Kansas zinc ores was calculated on the basis of the ores averaging a production of fifty-seven per cent., sixty-seven per cent. being the theoretically pure. Some of the ores as marketed would produce more than this, while the lower grades doubtless would not produce as much. To obtain an estimate of the metallic lead from the lead ore, twenty per cent. was added to the value of the ore. Lead ore is much more easily smelted than zinc ore, and the increase in value by the smelting operation is correspondingly less.

It may be thought that the smelter at Argentine, dealing so largely with ores from outside the state, should not be considered in a comparison of our various Kansas products with each other. It will be

difficult, however, for any one to show why a great smelting establishment of this kind does not do as much to increase the value of the crude ores or bullion shipped into the state and refined and marketed as a finished product, as our Kansas feed yard does to increase the value of a steer brought into the state from the range and fed Kansas grain for from thirty to ninety days. The market value of the finished product of the latter is included in the total animal products of Kansas in the above tables, so that it is entirely proper to consider likewise the finished products of the Argentine smelter.

The zinc smelters are much more important to Kansas in proportion to the value of their output. Zinc smelting is so difficult a task, so much capital must be invested, and so much labor employed, that it becomes an industry equal in importance to the mining of the zinc ore. The value of the zinc ore is usually more than doubled by the smelting processes.

Table VII is a summary of the total Kansas mining and metallurgical products for 1897, and also for the entire period since mining operations began.

TABLE VII.

SHOWING VALUE OF EACH OF THE MINERAL PRODUCTS OF KANSAS FOR 1897, AND SINCE INDUSTRY BEGAN.

Name of mineral product.	Values for 1897.	Totals by divisions, 1897.	Grand total of production.
NON-METALLIC PRODUCTS.			
Coal	$3,931,707 00		$51,335,808 00
Salt	417,626 94		4,289,200 94
Clay goods	265,320 27		1,430,304 00
Gypsum	252,811 00		1,680,407 00
Limestone	173,000 00		2,907,226 00
Sandstone	23,180 00		650,972 00
Natural gas	155,500 00		603,418 00
Petroleum	54,000 00		182,504 93
Hydraulic cement	64,000 00		600,666 00
Lime (estimated)	65,000 00		1,250,000 00
Sand (estimated)	45,000 00		350,000 00
		$5,447,145 21	
METALLIC PRODUCTS.			
Zinc ore, yielding metallic zinc	$2,795,683 28		35,000,000 00
Lead ore, yielding metallic lead	914,963 89		
		3,710.647 17	
SMELTING PRODUCTS.		$9,157,792 38	
Zinc smelting	$2,755,703 20		26,028,596 12
Argentine smelter output	15,077.048 34		...
		17,832.751 54	
Total	...	$26,990,543 92	*$126,309,102 99

*Exclusive of totals from Argentine refinery.

I.—GOLD AND SILVER.

WE have no mines in our state producing either gold or silver. Kansas, in common with other parts of America, has had various reports regarding the discovery of each of these metals. Such reports have reached this Survey from many different parts of the state, and, in fact, they were circulated long before the Geological Survey was organized. More than twenty years ago the scientific departments of the University were frequently called upon to pass judgment upon so-called gold finds, or silver finds.

The writer well remembers one instance when a party who had spent fourteen years in the gold and silver mining districts of California, Colorado, and the West came upon a granite boulder about fifteen feet below the surface while digging a well which was being sunk through the glacial drift material along the south bank of the Kansas river. This boulder had numerous specks of a golden-yellow mica within it which was mistaken by the "practical" gold miner for pure gold. He had learned that gold was not soluble in "aqua fortis" and upon observing that the mica likewise was not soluble in nitric acid he was sure it was gold.

Similarly, discoveries are made almost every year in the northeastern part of Kansas, the territory covered by the glacial drift materials. During the last three years in particular our University has been brought in contact with many such instances wherein honest citizens of our state have thought that gold existed in paying quantities on their farms, the mistake being due to a misapprehension of the nature of this same deceptive golden-yellow mica. Could the individual finding such deposits have forethought enough to test the mica scales with the point of a knife blade he would soon see for himself that they were not gold. Instead of being tough and malleable, as gold sand is, they are more or less brittle, and are easily subdivided into thin scales or plates which can readily be distinguished from gold by a novice.

Occasionally some one has insisted upon having such materials assayed, and not infrequently the result is the granitic boulders are found to contain a mere trace of gold or silver. Occasionally, also, samples from other parts of the state are sent in with instructions to have them assayed, some of which are entirely void of either gold or

silver, but occasionally some show a trace of one or the other of the metals. In one instance a rock was sent from Russell county, which, upon a careful assay, yielded about thirty-five cents to the ton, principally of silver, with the merest trace of gold. Likewise a piece of flint rock from somewhere in the Flint Hills region showed a trace of silver, according to a verbal report made the writer by Professor Bailey of the chemical department of this University. A specimen of pyrite sent in from Ness county showed a mere trace of gold, too small to be estimated, even though ten times the usual quantity was taken for the assay.

These results are similar to results obtained from all over the world wherever masses of the country rock are carefully assayed. Gold and silver have such a wide-spread occurrence in mere traces that it is commonly said: "If one were to carefully examine a handful of mud from the mouth of the Mississippi river he would find it contains a trace of gold and silver."

So far as this department knows, no conditions obtain anywhere in Kansas which would warrant a hope that any of the precious metals can be found in paying quantities. For the last five years, particularly, great effort has been made to examine with care all reported discoveries of gold or silver, and, as far as is known, typical samples from every locality where such finds have been reported have been carefully and systematically examined, with results as above stated.

Gold and Silver Smelting and Refining.

About twenty years ago a gold and silver refining plant was established at Argentine for the purpose of refining gold and silver bullion shipped in from other smelters, and for such other work as they might find profitable. The authorized capital of the company is three million five hundred thousand dollars, with a paid-up capital of three million dollars. At present the incorporated name of the company is "Consolidated Kansas City Smelting and Refining Company," and their business, "refiners of gold, silver, copper, and lead." They operate a smelter at El Paso and one at Leadville, from which they send the gross bullion to Argentine for refinement. Commercial conditions of the industry are such that this can well be done. Not only the gold and silver bullion must be shipped east from El Paso and Leadville, but also the lead as well, which constitutes the main part of the bullion. This bullion can be freighted east cheaper than the refined gold and silver could be sent the same distance by express, so that by shipping the bullion the shipment of the lead costs nothing.

In connection with the refining of gold and silver, other metal-

lurgical processes are engaged in, such as lead smelting, and the manufacture of commercial preparations obtained as by-products, partly from the copper and zinc of the ores. The business of the company has greatly increased from time to time, until at present it is the largest refining plant in the world. In 1896 they did about seventeen million dollars of business, and in 1897 their business was nearly as great. They now manufacture both blue vitriol and white vitriol. Instead of selling the refined copper in the metallic state they manufacture it entirely into blue vitriol, of which they made over a million and a half pounds in 1897. The refined and the smelted lead was only partially sold in the metallic state, but was largely changed in litharge and sold at an increased price. The company has in contemplation an enlargement of its blue vitriol plant so as to meet the growing demand for a larger output of this commodity. Already they have made profitable shipments to Europe, and find practically that the markets of the world are open to them.

The following table gives their gross production for the years 1896 and 1897:

TABLE VIII.

SHOWING THE OUTPUT OF THE ARGENTINE SMELTING AND REFINING COMPANY FOR 1896 AND 1897.

Gold and silver are expressed in fine ounces; copper, blue vitriol and litharge in pounds; and lead in tons. Fractions omitted.

Product.	1896.			1897.		
	Amount.	Coinage value.	Commercial value.	Amount.	Coinage value.	Commercial value.
Gold.......... oz.	198,348	$4,100,219	$4,099,856	232,417	$4,804,505	$4,804,079
Silver..........oz.	15,099,748	19,522,464	9,814,836	11,757,540	12,689,601	7,026,120
Copper........lbs.	4,438,700	....	443,000	....	....	....
Blue vitriol....lbs.	....	....	....	1,167,521	....	37,944
Litharge.......lbs.	....	....	....	2,881,124	....	112,353
Lead..........tons	41,206	....	2,266,000	45,806	....	3,096,550
Total values....	....	....	$16,623,691	....	....	$15,077,048

Scene in Lead and Zinc Mining District, Empire City.

Scene in Lead and Zinc Mining District, Galena.

II.—LEAD AND ZINC.

THE only locality in the state which has ever produced lead or zinc ores in paying quantities is the extreme southeast part of Cherokee county. Here the ores of each of these metals exist in phenomenal richness.

Historical.

It was in April, 1876, that the first discovery of lead ore was made in the county. For years similar mines had been in operation at Joplin and Granby and adjacent points in Missouri. In general character the surface rocks in this part of Kansas were known to be the same as those which produced the ores in Missouri. Different parties had prospected here and there up and down the little creek called Short creek, but nothing of value had been found. In April, 1876, while digging a hole, ostensibly for a well, on the farm belonging then to a Mr. Harper, a well digger was fortunate enough to come upon a mass of the purest lead sulphide (galena). No sooner was the fact noised abroad than different companies applied to Mr. Harper for the purchase of his farm, offering what seemed to be fabulous prices. Finally a company, composed principally of gentlemen from Baxter Springs, procured the land and immediately began prospecting for ore. Mining lots and town lots were surveyed, mining leases let, and temporary buildings erected, forming the new town which was rapidly springing into existence, and which was known as Bonanza, a name still borne by that particular locality.

Mining operations, however, were prosecuted slowly during the summer, largely from the fact that but few rich deposits of ore were found. The rapid growth of the village during the first few months gradually became checked, and twelve months from the time of the discovery there were perhaps fewer people living there than at the end of the first sixty days after the discovery was made known.

In the spring of 1877 the same prospector while digging in Short creek valley about a mile above Bonanza came upon a large body of pure lead ore which produced hundreds of dollars' worth of the ore. Again the excitement was renewed. Land was purchased; mining lots surveyed and leased; town lots bought and sold; and the narrow valley of Short creek soon changed from the quiet corn field of a farmer into the busy scene of activity and turmoil known only to few

mining towns of the world. Almost every shaft that was sunk found large quantities of lead ore near the surface. Two rival town companies came upon the scene, one of which got control of a considerable part of the land on the south side of the creek, and named the town Galena, the other of which controlled the greater part of the exceedingly productive valley and the upland to the north. This company named its town site Empire City. The story of the remarkable development of this area has been told in many newspapers from that time. It now sounds almost like a fairy tale; yet the same men who took part in the development of the mines and the establishment of municipal government in this little Short creek valley in 1877 still are living on the ground they then purchased, many of whom have become prosperous beyond the limits of reasonable hope in those early days. It is estimated that within three months from the discovery of ore in this second locality not less than twelve or fifteen thousand people had camped upon the grounds.

The first mining operations were crude in method and detail. The lead ore was found near the surface, so that but little hindrance was met with by water in the shafts. Chaos reigned supreme in local government. No one attempted to keep accurate account of the output of the mines, so that it will always be a matter of conjecture regarding the first few months', or even few years' operations. This chaotic tendency was increased by the mutual jealousy of the two town companies and the discord which resulted.

It was only a short time, however, until matters assumed a much more quiet and substantial form. Regular mining companies were organized; each controlled the properties belonging to it and conducted its operations in a systematic manner. The income from the ores brought vast sums of money into this country from the outside. Thousands of people were entirely dependent upon the success of the mines or upon the wages for a day's labor. The citizens of the adjacent farming communities soon learned that they also were to be greatly benefited by the development of the mines, for a strong and steady market was supplied for all of their products, and was brought almost to their very doors. Of the millions of dollars received for the lead ores and the zinc ores sold from Galena, a large portion has been immediately distributed throughout the farming communities near by. In this way, beneficial results have reached the whole community.

In the early period of mining many predicted that the ore deposits were superficial in character, and that they would soon become exhausted. As a result, the whole character of the surroundings bore the marks of such an impression. Improvements were all of a temporary character, something of a makeshift, something that will do

for today, with the trust that tomorrow will take care of itself. As time passed and more permanent bodies of ore were found such a feeling gradually disappeared, and a greater confidence in the permanency of the business was gained. This has been particularly noticeable during the last ten years. Improvements have been substantial and extensive. Good business blocks have been erected, permanent homes have been built, streets macadamized, and general improvements made, giving the erstwhile mining camp the appearance of a substantial business city. By one who visited the locality during 1876 or 1877, the present conditions can hardly be realized. Extensive mining machinery is now in operation throughout the whole territory. Stronger companies are formed for conducting such portions of the business as cannot be carried on by the individual miner. Smelting establishments are in operation, railroads have long since found their way into the mines, and everything in connection with the mining operations, and with the city as a business center and the home for an intelligent and cultivated citizenship, is apparent. The Galena and the Empire City of today constitute attractive and desirable locations.

Character of the Ores.

The lead ores and the zinc ores are so intimately associated that they cannot well be separated in a description of their occurrence. Scarcely a shaft has been operated that did not produce ores of both metals. Frequently the same shovel of earth will have the two mixed in about equal quantities. Then, often, the same fragment, smaller than a man's hand, will be partly composed of one and partly of the other. It is a rare occurrence for a mining company to fail to produce both lead and zinc ores in paying quantities during one week, provided they find ore of any kind.

Lead Ores.

Galena.—The prevailing lead ore is the ordinary lead sulphide, PbS, or galena, an ore which, when pure, is composed of 86.6 per cent. lead and 13.4 per cent. sulphur, with a specific gravity of 7.4 to 7.6. It is dark steel or bluish black in color, differing in its general appearance from any other ore. It is always crystalline in structure, most commonly forming cubes with their solid angles truncated with faces of the octahedron. Such cubes differ greatly in their dimensions. Some of them are almost microscopic in size, while others are from six to eight inches across their faces. The largest cubes ever seen by the writer came from a shaft on the Battlefield land operated by the Messrs. Carney & Aldrich. The specimen in question was shown at the World's Fair in the Kansas exhibit. It was almost pure lead ore, some of the cubes of which, by actual meas-

urement, were a little over seven inches in length along their longest edge.

Galena always has a very perfect cleavage in three directions at right angles to each other. Sometimes, where the ore is found in rocks, the external crystalline form may not be apparent, but the cleavage is always very perfect, so much so indeed that if the ore be broken in any manner whatever it always breaks along the cleavage lines, yielding fragments with bright surfaces and bounded by planes at right angles to each other.

Purity of Galena.— Galena in Kansas is rarely contaminated with other materials to any considerable extent. It is one of the peculiarities of this ore that usually it is exceptionally free from chemical impurities. This is illustrated by the fact that the market quotations of the price of ore always give the same price for all lead ore, there being no such thing as first grade, second grade, etc. Some consignments of ore are docked a little in weight on account of the mechanical impurities — flint rock, gravel, etc.— that the ore contains, but no lead ore buyer has ever made a variation in price on account of impurities contained within the ore itself.

In other parts of the world the galena frequently contains traces of silver, arsenic, antimony, and similar impurities. The analyses of galena from Kansas have failed to show the presence of any such materials in appreciable quantities. It is probably true that no mining locality in the world produces a purer galena or one more easily smelted than the galena from Cherokee county, Kansas.

Secondary Lead Ores.—Along with the galena occasionally a small amount of another ore of lead is found. In some places in the mines, particularly in dry ground, larger or smaller masses are found of an ore that the miner calls "dry bone," which sometimes is a lead ore, and sometimes a zinc ore, or which may be a mixture of the two. If a lead ore it is probably a lead carbonate, the mineral cerusite; but if not this then it is sure to be a lead sulphate, the mineral anglesite. These two ores are white in color when pure, and are fairly rich in lead. They have been produced by the weathering action upon galena. In some way the atmospheric conditions sometimes change the galena into a soluble product which may be carried some distance by percolating water. If conditions are favorable it will be deposited not far away in the form of a white, generally amorphous, lead carbonate or lead sulphate. Such deposits frequently are mixed with more or less clay and are thereby given a yellow color.

Commercially such ores in Kansas are of little importance on account of their scarcity, and therefore need not be considered further here.

Zinc Ores.

Zinc Blende, or Sphalerite.— The important zinc ores of Kansas are two in number, with a third one occasionally found. The most abundant, and hence the most important, is the common sulphide, zinc blende, or sphalerite, ZnS, which when pure is composed of sixty-seven per cent. of metallic zinc and thirty-three per cent. sulphur, with a specific gravity of 3.9 to 4.1. Unlike lead sulphide, zinc blende generally is impure, usually containing a variable amount of iron sulphide as an isomorphous mixture with the zinc sulphide, and which therefore cannot be separated by a concentration process outside of the smelting works. This gives rise to a variety of colors which the ore may have. The artificially prepared zinc blende is white, but a small trace of an iron compound added changes the white into a darker color. The purest zinc blende in nature is never white, but sometimes it may be found with so small a proportion of impurity that its color is only slightly yellow. From this it passes by imperceptible gradations through the various shades of amber, resin, and steel gray into an almost black mineral. The common name for the ore in the southwestern mining locality is "jack," and the various colors are designated by such terms as "resin jack," "gray jack," "steel jack," "black jack," etc.

Along with these impurities are others which are mechanically mixed with the ore, such as bits of clay, flint rock, and other associated materials. As the specific gravity of the zinc blende is less than that of the galena, it is correspondingly more difficult to completely separate such impurities from the ore. As a result the market quotations always show a variation in the price of zinc ore. Some samples, in fact, will sell for nearly double what others bring, a condition which is in strong contrast with that already given for the market quotations of lead ore.

Other Ores of Zinc.— The other ores of zinc, while not abundant, are of more importance than the secondary ores of lead. Zinc sulphide or zinc blende is easily rendered soluble by atmospheric changes. While dissolved it is readily carried here and there by the ground water, and sooner or later becomes again changed into an insoluble form and is deposited in various openings, associated with the other ore bodies. One never knows, therefore, when sinking a shaft, whether he will find the higher grade of ore, zinc blende, or the other less profitable ones, but as in this locality the blende is the only ore of wide occurrence, the others are rarely encountered.

The most common of these secondary ores are two in number — the zinc carbonate, smithsonite, $ZnCO_3$, and the hydrated zinc silicate, calamine, $Zn_2SiO_4 + H_2O$. Of these, the latter is much the more

abundant, and is frequently found in large quantities in different places in Missouri, particularly about Granby; but thus far no considerable quantities have been found in Kansas. It, like the secondary lead ores, is sometimes called "dry bone" by the miners, but more recently the term "silicate" has been applied to it, which is frequently abridged by the miner into the shorter word "silica." The commercial value of this silicate of zinc is so little that it would hardly pay to operate a mine for it alone. But if one is mining for the other ores and finds a body of this it is remunerative to raise it and ship it to market.

Associated Minerals and Ores.

Here, as elsewhere, certain other minerals and ores are frequently associated with the lead and zinc ores. Of these the most abundant is the common ore pyrite, a double sulphide of iron, FeS_2, the "mundic" of the miners, the specific gravity of which is 4.95 to 5.1. It is found in nearly every shaft in the mining district, but rarely in sufficient quantities to be objectionable. When mixed with lead ores the difference in gravity is sufficiently great to admit a separation of the two without any particular difficulty, but when mixed with zinc ores the difference in the gravity is so little that a complete separation of the two is a difficult task. The presence of pyrite in zinc ore is also objectionable on account of its action on the retorts in the smelting furnaces. A small quantity of it will therefore reduce the price of the ore greatly.

The other most common impurity is copper pyrite, an ore which is exceedingly valuable as a source of copper when occurring in sufficient quantity, but which is found here in many of the mines covering the surface of the zinc and lead ore crystals with the small, triangular-faced crystals common to this mineral. Thus far no instance has been observed where it was sufficiently abundant to warrant an attempt to save the copper. However, it is so frequently found that it need not surprise any one should larger quantities of it be located.

The most abundant mineral associated with lead and zinc ores is calcite, $CaCO_3$, the carbonate of calcium, often called calc spar, the "tiff" of the miners. This mineral is simply crystallized limestone, and is found in cavities of limestone all over the world, having been produced directly from limestone. In many places it forms beautiful crystals, some of which are from one to two feet in length, and from six to eight inches in diameter. The largest ones thus far observed came from the Gracie Clark diggings, about two miles north of Empire. Elsewhere it has entirely filled the cavities in the rock, be they large or small, and is void of external crystalline form. Always,

however, the characteristic cleavage of the mineral is apparent, giving the rhombohedral or diamond-shaped blocks upon breaking. Sometimes it is almost perfectly clear and transparent, the "glass tiff" of the miner; elsewhere some staining matter clouds it and gives it a particular color—light buff, greenish, bluish, or whatever it happens to be.

Calcite is so frequently associated with lead ore and zinc ore that it has generally been looked upon as an indication of the ore wherever found. People throughout the whole country, when digging for lead or zinc ores, like to find quantities of it. In so far as it represents an open condition of the ground it may possibly be that it does signify the probability of a valuable ore being found. Aside from this, however, it is doubtful if there is any relation between the two.

Barite, or heavy spar, the sulphate of barium, $BaSO_4$, sometimes is found associated with both the lead ores and the zinc ores, but never in considerable quantity. Fluor spar, calcium fluoride, $CaFl_2$, also has been found in a few places, but never to any considerable extent.

Aside from these no minerals of any consequence have thus far been observed by the writer as occurring in the lead and zinc mining district of southeast Kansas.

Geography of Lead and Zinc Ores.

The only locality in the state where lead and zinc ores are mined at the present time is in the extreme southeast corner of Cherokee county. Here, from an area scarcely equaling four miles square, the whole of the lead and zinc ores have been mined that have ever been shipped from Kansas. The general character of the country is rugged, narrow valleys skirting each little stream, and hills rising on either side from 100 to 200 feet above the valley.

The western limit of the area is approximately marked by Spring river, although some mining has been done west of this stream. The southern limits of the mines as at present operated may likewise be placed at Shoal creek, a tributary of Spring river entering from the east. Here also this limit is not an exact one, as some mining has been done beyond. The eastern limit is the state line, valuable mines existing immediately beyond in Missouri. The northern limit as known at present is the Gracie Clark mines, which lie about two miles north of the Memphis railroad station, Galena.

The geographical limits as above given do not really present an exact idea of the area from which the ore has been obtained. The sixteen square miles, probably, is too large by almost one-half, if exact measurements were made. Many confidently expect that the productive area will be widened with future development, and for

every reason, as far as geologic conditions are concerned, this may be expected.

Lead and Zinc Ores in Other Parts of the State.—No ores of lead or zinc have ever been mined in marketable quantities anywhere in Kansas outside of the Galena district. About thirty years ago considerable excitement was raised regarding lead ores in the vicinity of Pleasanton. Prospecting was carried on for some time, and many people thought valuable deposits of ore existed there. The results have failed to justify such hopes, as nothing has been obtained, not even enough to send a single consignment to the markets.

To the west, in the vicinity of Walnut and Erie small amounts of zinc ore have been obtained. Only a few years ago many sensational rumors were afloat regarding the discovery of great ore beds near Erie. The writer visited this locality and conversed with a few people who had been interested in the prospecting enterprises, but at that time was unable to meet the superintendent of the company. He was shown a number of samples of ore which were genuine zinc blende, all of which were reported to have been obtained from that immediate locality. During the latter part of 1897 a student of the University brought samples of limestone from near Walnut which contained crystals of zinc blende, some of them being nearly an inch in diameter. Professor Bailey is authority for the statement that small quantities of zinc blende have been found in the rocks near Lawrence. It is common knowledge that small quantities of zinc blende are frequently found in the coal-mining areas of both Kansas and Missouri.

These facts show conclusively that the zinc ores particularly, and the lead ores to a lesser degree, exist in small quantities in many localities outside of the Galena area. No one has ever succeeded, however, in finding more than mere traces of the ore, and no one would be justified in making a prediction regarding the possibilities of a larger output. The general geologic conditions of these areas discourage the hope of profitable mining in any of them.

In the west-central part of the state, occupying a zone stretching across from western Jewell county to the Arkansas river, in Finney and Kearny counties, a resinous colored calcite exists in peculiarly formed masses commonly called "septaria." Such masses are frequently found immediately at the surface of the ground, the soft shales surrounding them having been worn away. Not infrequently a level area of from 40 acres to 160 acres in extent has such rounded masses of calcite exposed on the surface, giving a general appearance of hay shocks in the distance. Ever since the country was settled people have occasionally been more or less interested in knowing what these peculiar formations are. They have frequently been called zinc

ore, probably on account of their strong similarity in color to some of the resin-colored zinc blendes. Every year since the writer has been located at the University he has received many samples of this and associated material from widely separated localities along the line of outcroppings just given with requests to determine whether or not the samples are zinc ore. The associated materials which have been sent in are variable and numerous in kind. Altogether perhaps twenty different samples have been examined, sometimes by the writer in person, sometimes by the chemical department of the University directly. It must be said that in every instance not a trace of zinc has been found in the specimens examined, although some of them were described by the sender as containing as high as forty per cent. metallic zinc.

Geology of the Ore-Bearing Formations.

The lead and zinc ores of southeastern Kansas occur in the Mississippian or Subcarboniferous limestone formation, which has a wide exposure in southwest Missouri, northwest Arkansas, and southeast Kansas. In Kansas but a small area is covered, one forming approximately a triangle in the southeast part of the state, six miles wide at the base along the south line and ten miles high along the east. The northwestern limit is approximately determined by the position of Spring river, but not entirely so, as the same formation is found in many different instances either at the surface or only a few feet beneath for a few miles to the west of Spring river. In Missouri, according to the geological maps of that state, the Subcarboniferous covers thousands of square miles in the southwest corner, and forms a narrow strip reaching to the northeast to the limits of the state. To the south of Missouri it covers a portion of northeastern Indian territory and a large part of northwestern Arkansas.

Lead and zinc ores have been found in greater or less extent in many places in southwestern Missouri, northwestern Arkansas, and northeastern Indian territory, but the heaviest ore deposits thus far discovered are confined to a small area lying in the vicinity of Carterville and Joplin in Missouri, and Galena in Kansas.

This particular geological horizon is different in many respects from any other one known in the whole geologic column. It is essentially a limestone formation, but here and there, in many places throughout its vertical and horizontal extent, the limestone is almost entirely replaced by flint rock, which forms extensive masses, sometimes measuring hundreds of feet in thickness. The flint seems to be primary in origin, the indications implying that it was formed at the same time the limestone was. It is frequently almost pure silica, often

containing but a mere trace of foreign matter. Its general character has been described so often in various places that details need not here be given. It does not exist in equal abundance uniformly throughout the Subcarboniferous formations. In some places the limestone constitutes the permanent feature of the terrane, while elsewhere the limestone is scarcely visible and the flint is prominent.

Usually the ore is found entirely within the flint masses; that is, in openings surrounded by the flint beds. There is practically no instance known of the ore occurring in the limestone, as is so generally the case in other lead and zinc mining districts, such as southeastern Missouri, northeastern Iowa, and southwestern Wisconsin. The flint has been fractured to so great an extent that it would be difficult to obtain a cube six inches across which did not have a number of fractures within it. Associated with the limestone as it is, large quantities of the limestone may have been dissolved out, leaving the flint to appear all the more prominent. In some way, and by some processes, myriads of openings, of almost an infinite variety in shape and size, have been produced. The rock volume has been greatly contracted, either by the dissolving out of the limestone or other rock material, or some other process, producing underground open spaces. Here is a chamber some feet in extent; there is a seam unaccountably widened to six or twelve inches; here is a fracture line one sixteenth to one thirty-second of an inch in width — cavities of all descriptions and of all sizes. Such cavities are more or less filled with the lead ore and the zinc ore. No matter how irregular in size, shape, or position, the ore has been deposited in them from watery solutions.

Along with the ore is a variety of silicious material, secondary in origin, which also has been deposited from water. At some of the mines it constitutes the main mass of material in the dump piles, while elsewhere it is present to a much less extent. This material has been named jaspylite by Jenny, and is fully described by Winslow in his reports on the lead and zinc ores of Missouri. It is most intimately associated with the ores wherever it is found, the two apparently having been deposited at the same time.

The depth at which ore is found varies exceedingly. In some places it is observed at or near the surface; elsewhere a shaft must be carried 100 feet or more to reach it; while in many places it would seem from the small amount of deep prospecting done that ore exists at a much greater depth — from 200 to 250 feet — with no apparent indications of the same near the surface. Many instances are now known where a territory once prospected to a considerable depth and abandoned as unproductive has since become a great producer by deeper mining. The most notable of these, perhaps, is the North Empire

territory. Here, in the little valley, many shafts were sunk in the early days of mining, from 1877 to 1880. Almost no ore was found. After nearly fifteen years of waiting it was discovered that one of the richest bodies of ore ever yet reached lay but a few feet beneath the bottom of these old shafts. During the past eighteen months perhaps the North Empire area has produced more ore than has ever been taken from an equal area in a similar length of time, unless it should be the Short-creek valley where lead ore was first discovered.

There is no regular geological difference between rocks near the surface and those at a greater depth. It cannot, therefore, be determined why, in some cases, the ore is so near the surface and elsewhere so far below. Occasionally a limestone mass is found before the shaft has reached a very great depth, and this must always be passed before ore in large quantities can be found. In some places in the North Empire territory limestone has been drilled through and large ore bodies found immediately underneath. It seems that in some way the depth of the ore may possibly be dependent upon the water level in the ground. Where the conditions have been such that the water level was far from the surface the ore usually is found likewise at a great depth. It will not do to pass judgment on this even by using the water levels as we now find them, for in some parts of the country, particularly on the land belonging to the South Side Mining Company, large bodies of ore lie above the present water level and can be taken out without any difficulty from water in the mines.

Throughout the whole mining region of Galena and Joplin a belief has been prevalent among the miners that the ore rarely, if ever, occurs beneath a body of limestone. It is a common saying even yet that if a limestone is reached in sinking a shaft the shaft should be abandoned. This is generally true provided the parties do not have sufficient capital to carry the shaft a number of feet in limestone, for frequently the limestone bed will be from ten to twenty or even more feet in thickness, and the expense of sinking a shaft through such a formidable obstacle is greater than many of the prospectors can bear. It has been proved in many places during the last year, however, that the mere fact of the existence of a bed of limestone at any particular place practically argues nothing of the possibility of a large ore bed lying underneath. Wherever the flint exists in large bodies, and has many openings through which the water can pass, there one may expect to find the ores, entirely independent of the character of the material which exists twenty-five or fifty feet above.

Mining Methods.

In the early days of mining the methods were quite rudimentary. A drill driven by hand, a few sticks of giant powder, a home-made windlass, rope, and a bucket made from one-half of a barrel, constituted the main part of the miner's outfit. For washing the ores, in the early days of Joplin, a sluice-box, a wooden trough open at each end, placed in a stream so that the water could run through it, was the main appliance used. When water gave trouble in the shaft the same bucket which lifted the rock would likewise lift the water. A little pond would be extemporized near the shaft for washing the ore in the sluice-boxes. Soon, however, advanced methods were used, the windlass gave place to the horse-power hoister, which is still almost universally employed by all prospectors who have mines located some distance away from a steam plant.

The modern mine is equipped with a steam hoister, with a large steam pump, and with many other appliances to facilitate the underground operations similar in many respects to the most improved methods of mining for other ores. A large rectangular shaft is sunk until a heavy body of ore is reached. The pump is carried downward some feet below the lateral tunneling, so that it may drain the chambers which are opened. Lateral tunnels are driven in various directions, following any particular lead of a find of ore body, so that the largest body of ore may be taken out. No particular system is employed in making the chambers. The occurrence of the ore is so different from the occurrence of coal, for example, that the requirements are exceedingly varied. The roof in most cases is strong and firm, so that in many cases the chamber may be made hundreds of feet in length and a hundred feet wide. The ceiling of such a chamber frequently is from fifty to seventy-five feet in height, the whole of this space having been occupied by rock called "pay-dirt," so that the whole of the mass has been blasted out and hoisted to the surface for the mills. The underground conditions in such mining localities are, therefore, exceedingly varied. In some places almost the whole surface is undermined, so that frequently the ceilings will cave, letting the whole surface fall. Any one visiting these mining localities can form some idea of the extent to which the underground excavation has been carried by the volume of débris now covering the surface.

The improvements recently made in the underground mining are no greater than those in connection with ore-dressing processes. The sluice-box of the early days gave way to the "hand jig," and that in turn to the steam separators, which are now extensively used in connection with the steam-power crushers so common throughout the whole region.

The "hand jig" is an apparatus consisting essentially of a large, water-tight wooden box, on the inside of which is suspended a similar box with the bottom made of iron rods an inch or so apart, so that the water can freely pass through the box. The outer box is filled with water and the inner with the ore to be washed. By a simple movement of a lever an up-and-down motion is given to the inner box; as the box moves down the water moves through it, lifting the lighter part of its contents to the upper surface. After a few minutes' shaking of the "jig" it is found that the ore has all settled to the bottom and the lighter rock is lying on top so that it may readily be shoveled out. This "hand jig," in its improved form, even to-day, is a most satisfactory appliance for washing ore at outlying mines.

The large mines where the ore is abundant are always operated by stationary steam-engines, and the ore is crushed and washed by machinery driven by the same steam power. The modern appliance, in its entirety, consists of a large building covering the shaft; with a large steam power for operating the hoister, with cages similar to those used in coal mines and other well-conducted mines, for operating the pump with a capacity of from one-fourth million to one-half million gallons of water per day, for running the crusher with a capacity of from fifty to a hundred tons of rock every ten hours, and for operating steam "jigs" with a capacity sufficent to wash all of the ore crushed. Such an outfit costs from $5000 to $15,000, some plants now in Galena being even more expensive.

Value of Mining Property.

It is practically impossible to give a definite idea of mining properties in this region. Some pieces of land have produced almost fabulous amounts, while others have been less productive. There are few tracts which have ever been operated in or near the center of the mining locality that have not developed into good mining properties. It is estimated that the eighty acres of land belonging to the South Side Mining and Manufacturing Company has produced ore exceeding two million dollars in value. The forty acres known as the "Battlefield" land is another exceedingly rich piece which has produced more than half a million; likewise, other pieces have been equally productive.

The mere fact that a certain area has been abandoned shows little or nothing with reference to its possibilities. This is well illustrated in the North Empire lands. Early in the history of the country, as already explained, scores of prospect shafts were sunk to a depth which in those days was considered the limit of profitable mining. After a lapse of more than fifteen years of idleness, a fortunate pros-

pector began deepening one of these old shafts. He had gone less than four feet when he came upon one of the largest and richest bodies of ore ever yet discovered. In a few weeks' time the whole North Empire valley was alive with prospectors, almost every one of whom found large bodies of ore at about the same depth. For 1896 and for 1897, the two years during which mines were worked here, it may be stated roughly that more than half of the total output from Galena came from this locality. The value for these two years reached the aggregate of over four million dollars, showing that the territory counted as good for nothing for over fifteen years is capable of producing over two millions a year by going only a few feet deeper than the shafts had been carried.

Statistics for the Output of Ore from Galena.

In the early days of mining no statistics whatever were gathered or were available; nothing but the merest guess can ever be given for the output of this locality during the first ten years of its existence as a mining community. In 1882 the writer had a little experience in trying to gather statistics of this place. He finally abandoned the enterprise on account of the total lack of confidence to be placed in any sum total he might reach covering these early years. Not until about the close of the first decade were any figures kept that can be considered of any value. Mr. Elliott, of the Galena mining bureau, has prepared tables showing the probable output for the decade from 1886 to 1895, inclusive, giving as his estimate for this period, 291,961 tons of zinc ore, and 102,227,801 pounds of lead ore; the total aggregating a value of $8,041,801.22. The average value of the lead ore for the decade is a little under $21 per thousand, and of zinc ore a small fraction over $20 per ton.

The decade from 1877 to 1886, inclusive, probably was more productive in value than the one represented by Mr. Elliott's figures. Those who were eye witnesses of the enormous amounts of lead ore obtained from the Short creek valley during the first few years generally admit that the equal of it has never been reached since then. The price for the first decade was probably double what it was later. For example, the price of lead in the New York market in 1877, the year the Galena mines were opened, averaged $5.50 per hundred pounds, while in 1884 the average price was $3.73½ per hundred pounds.

Early in 1893 Mr. E. St. George Noble, of Galena, estimated that up to that date the mines had produced about twenty millions in value. Since that date they have produced about six and three-fourths millions, as shown by the tables following. Perhaps as close

an approximation as can be made of the whole matter is to estimate that during the period from April, 1876, to December, 1897, the total value of the output of the products of the mines, at the mines, reaches from twenty-five million to twenty-six million dollars.

The tables which follow have been gathered from different sources. Those from 1886 to 1895, inclusive, are based upon statistics gathered by Mr. Elliott, of Galena, and those for 1896 and 1897 are from the *Engineering and Mining Journal.*

TABLE IX.

SHOWING OUTPUT OF LEAD AND ZINC ORES, GALENA DISTRICT; CHEROKEE COUNTY, KANSAS.

From January 1, 1886, to December 31, 1897.

Year.	Zinc Ore.			Lead Ore.			Total value of output.
	Tons, 2000 lbs.	Average price per ton.	Value.	Pounds.	Average price per 1000 lbs.	Value.	
1886 ..	31,768	$18 50	$587,708 00	5,924,284	$29 50	$174,766 38	$762,474 38
1887 ..	32,795	19 00	623,105 00	6,152,380	26 25	161,499 98	784,604 98
1888 ..	33,391	21 00	701,211 00	5,248,000	15 50	81,344 00	782,555 00
1889 ..	32,950	24 00	790,800 00	7,985,000	23 00	183,655 00	974,455 00
1890 ..	21,675	23 00	498,525 00	8,317,927	21 14	176,176 28	674,701 28
1891 ..	20,641	21 51	454,102 00	7,204,420	25 16	182,271 83	636,373 83
1892 ..	23,811	20 00	476,237 78	14,376,340	21 00	301,903 14	778,140 92
1893 ..	25,028	18 85	471,789 00	10,279,180	19 00	195,314 42	667,103 42
1894 ..	28,670	17 10	490,257 00	11,634,980	16 82	195,794 66	686,051 66
1895 ..	41,232	19 68	812,792 00	25,075,290	19 28	482,548 75	1,295,340 75
1896 ..	62,232	22 51	1,401,307 83	28,123,170	16 02	450,529 90	1,851,837 73
1897 ..	59,451	25 17	1,492,663 04	30,369,360	25 10	762,469 96	2,255,133 00
Totals,	413,644	....	$8,800,497 65	160,720,331	....	$3,348,274 30	$12,148,771 95
Estimated value of metal from same..............			16,073,035 00	....	....	4,017,829 00	20,090,864 00

Estimated total production of ore from 1876 to 1897, inclusive, $25,000,000.
Producing metallic zinc and lead with value of $35,000,000.

Lead Smelting.

Historical.— Early in the history of Galena, the South Side Mining and Manufacturing Company, Col. W. B. Stone, president, established lead-smelting furnaces at Galena. Their furnaces consisted of "Scotch eyes," and were located in the western part of the town Galena as it then existed. These furnaces were continued in operation about eight years, when, through business relations as regards the price of ore, the cost of smelting, etc., they were shut down. Nothing more was done in the line of lead smelting at Galena until 1897. During the latter year two different companies established smelters at Galena and began operations on a tolerably large scale.

During the interim, from the closing of the first Galena smelters

to the establishing of the latest ones, the Galena lead ore was principally shipped to the Joplin smelters. A small proportion of it went to the West to supply a demand for lead in the gold and silver smelting furnaces of the Rocky Mountain district. Occasionally, during the last few years, a part of the ore was shipped to the refining works at Argentine. This latter company, as has already been explained under the head of gold and silver smelting, is doing a large business in refining gold and silver bullion. As a result it is sending vast quantities of metallic lead onto the market, and has established such a reputation as a producer of pure soft lead that it is enabled to make unusually advantageous sales. During the latter part of 1897, particularly, this company entered the markets of Galena and Joplin and bought large quantities of lead ore, which were shipped to the smelter at Argentine.

The peculiar combination of circumstances — a high protective tariff on imported ores, a return of prosperity, and the business activity resulting therefrom, and other matters which outsiders will perhaps never fully understand — made it so that there was an unusually sharp competition between the buyers of lead ore. This was carried to such a high degree that the largest lead-smelting establishment of Joplin shut down for months, as did also one of the newly established smelters at Galena. The price of ore for the last half of 1897 was correspondingly high, as can easily be determined from the statistical tables given later.

Lead-Smelting Processes.—The smelting furnace most commonly used throughout the whole of this Southwestern district is the improved "Scotch eye." As usually built a considerable amount of the metallic lead is volatilized and escapes through the smoke-stack. Years ago the Lewis patented process for saving these metallic fumes was employed at the Moffet smelter in Joplin. This consists essentially in suspending a large number of woolen bags from the ceiling of a large chamber, the lower ends of which are fastened over registers through which the whole of the material escaping through the smoke-stack must pass. The gaseous products pass slowly through the bags, while the solid products are strained out. The lead vapor escaping from the furnace is soon changed into lead oxide, which in turn is changed into lead sulphate by the sulphur fumes likewise escaping through the smoke-stack. The product is therefore got in the shape of lead sulphate, and when properly separated from the fumes is used as a pigment for white paint. Since the shutting down of the Moffet smelter, the same process has been used by the Pitcher Smelting Company, of Joplin. The new smelters at Galena have attachments for accomplishing this same end, although very different

Interior View of Lead and Zinc Mine, Galena.

The Cherokee-Lanyon Zinc Smelters, Pittsburg.

in construction. It is claimed by operators of this process that the savings are enough to make a handsome margin of profit, so that the old-fashioned "Scotch eye," with no attachments for saving the waste fumes, probably has gone out of use.

Charcoal is the fuel universally used in these lead-smelting furnaces, although ordinary coal is used, of course, for generating steam with which to drive the machinery. Lead ore is particularly easily smelted; therefore the cost of the fuel is but little.

Zinc Smelting.

The processes of smelting zinc ore are much more elaborate than those of smelting lead ore, and the cost correspondingly greater. It is estimated that three and one-half tons of fuel are required, upon the average, to smelt one ton of the ore. This condition has made it desirable for the great zinc-smelting establishments to be located at or near the coal-fields, as thereby only about one-third the freightage is required to bring the ore and the fuel together. The nearest coal-fields to the Galena and Joplin zinc mines are the coal-fields of Cherokee and Crawford counties, Kansas. As early as 1873 a zinc smelter was established at Weir City, and ore was drawn by teams from the mines to the smelter. It was but a short time until other coal mines were opened in that vicinity, particularly about Pittsburg, a town which was established on account of the rich coal-beds at that place. Zinc smelters soon sprang up in great number, and with them came a correspondingly increased activity in the zinc-mining district. In these early days, it is true, large quantities of our zinc ore were shipped to the smelters at La Salle and Peru, Ill., and to a few other places. Our Kansas smelters, however, have long been so extensive that they have consumed much more ore than our Kansas mines could produce. The Kansas and Missouri mines are so close together that no difference could be made between them by the ore buyers. They consequently purchased from the Kansas and Missouri mines indiscriminately to ship to the Kansas smelters or to the other smelters. It is not proper to say that all of the Kansas ore is smelted on Kansas territory. It is proper to say, however, that a very much larger amount of ore is smelted on Kansas territory than is produced from Kansas mines, as much more than half of the Missouri ore is shipped to Kansas smelters.

The zinc-smelting process is too elaborate for description here. The old-fashioned Belgian furnace is employed, the modifications being confined to improvements of a mechanical nature in methods of handling the ore. The process consists, first, after the ore is crushed, in passing it through a calcining furnace in which it is throughly roasted

until all the sulphur is removed and the metal is left behind in the form of an oxide. It is then intimately mixed with a proper amount of carbon, generally in the form of coke, which has been produced on the grounds, and is then placed inside a clay retort which is heated externally until by the reducing action of the carbon the whole of the zinc oxide is reduced to a metallic state. The heat of the furnace volatilizes the zinc as fast as it is deprived of oxygen and drives it into a conical clay receptacle attached to the retort, but which projects outside of the furnace. Here it is cooled to the liquid state and is drawn out and molded, after which it is ready for the market.

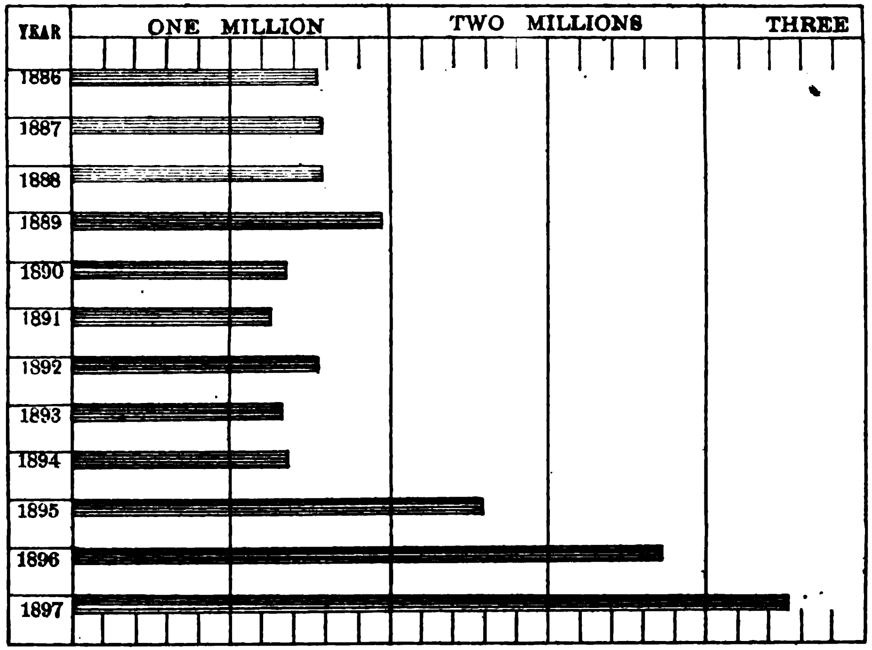
The following table shows the extent to which zinc smelting has been carried in Kansas:

TABLE X.

SHOWING AMOUNT AND VALUE OF METALLIC ZINC PRODUCED AT KANSAS SMELTERS, 1882 TO 1897, INCLUSIVE.

Year.	Amount in short-tons. (2000 lbs.)	Price per ton in New York.	Total value.
1882	7,366	$110 60	$814,679 60
1883	9,010	90 60	816,306 00
1884	7,859	89 60	704,466 40
1885	8,502	86 80	737,973 60
1886	8,932	88 00	786,016 00
1887	11,955	92 40	1,104,642 00
1888	10,432	97 80	1,020,269 60
1889	13,658	100 00	1,365,800 00
1890	15,199	108 60	1,650,611 40
1891	22,747	100 40	2,283,798 80
1892	24,715	92 20	2,278,723 00
1893	22,815	80 00	1,725,200 00
1894	25,588	70 20	1,896,277 60
1895	25,775	72 00	1,855,800 00
1896	20,759	79 88	1,657,328 92
1897	33,443	82 40	2,755,703 20
Totals for 16 years	268,755	....	$23,453,596 12
Estimate of zinc smelted previous to 1882			2,575,000 00
Total			$26,028,596 12

Univ. Geol. Surv. of Kans. PLATE I. Annual Bulletin on Mineral Production, 1897.



Annual metallic value of lead and zinc ores produced at Galena from 1886 to 1897, inclusive.

III.—COAL.*

COAL has been mined in Kansas to a limited extent for over thirty years. In those early days, however, the amount mined was very small. Immediately after the war of the rebellion settlers poured into Kansas by the thousands. It was during the summer of 1866 that Cherokee and Crawford counties first received any considerable number of settlers from the North. Their choice of homes lay close to the larger streams: Cow creek and Spring river on the east, Lightning creek and Neosho river on the west, and the tributaries of the Drywood and the Neosho, in Crawford county. The wide prairie region in the middle of the two counties was hardly occupied until the summer of 1867.

These early settlers in southeast Cherokee county began mining coal in the fall of 1866. The coal-beds they operated upon were some of the thinner and lower veins, now entirely abandoned. One vein of coal along Brush creek in Cherokee county was opened up and mined for local supply early in the winter of 1866 and 1867. The vein was about twelve inches thick. The surface stripping amounted to but little, and with plow and team it was a very little matter to lay bare a considerable area and to dig up the coal. This supplied the local demand and also furnished some for the adjoining territory in Missouri, to which market it was conveyed by wagon. Some years later the heavy beds of coal now so extensively mined in Cherokee and Crawford counties were discovered where they come to the surface, and mining operations began by the stripping method.

To show that in those early days no one suspected the existence of coal where it is now mined so extensively, it is only necessary to mention that the railroad company now known as the Kansas City, Fort Scott & Memphis, which owned all of the good coal lands in Cherokee and Crawford counties, sold nearly all the same for agricultural purposes, without reserving the mineral rights, never suspecting that such untold millions of tons of coal existed only a few feet beneath the surface of the lands which they sold. After it became fully established that such large areas were underlaid with such heavy beds

*This Survey now has almost ready for publication a report on the coals of Kansas, treating the subject in a more elaborate manner. As this special report is to be issued so early, the discussion of coal here will be limited to mere outlines.

of the best bituminous coal; mining operations increased with great rapidity.

The outcropping of the heaviest coal-beds of the area forms an irregular line extending northeast and southwest. Weir City was the first city founded upon the coal-fields, followed by the location of Pittsburg, nine miles to the northeast, and this, in turn, by the numerous coal-mining villages, such as Scammon, Mackie, Chicopee, Litchfield, Nelson, Fuller, and other places so well known in that part of the state. At the present time more than two thirds of the coal mined in the state comes from these two counties, nearly all of which is taken from the same coal-bed, the coal-vein commonly known as the "Weir City" or "Pittsburg heavy vein."

Along with the development of mines operating in these heavy coal-beds, lesser beds have been operated, particularly in Cherokee county, by the stripping process, where they are exposed near the surface. The price of coal for the last few years has been so low that it has been unprofitable to work these lesser beds, the individual farmers usually finding it profitable to buy coal from the market rather than to spend time mining it from their land. A large area to the southeast of Columbus, in Cherokee county, is the locality in which the greatest part of this "strip-pit" mining was formerly carried on, but which has since been abandoned.

Almost synchronous with the development of the coal mines in Cherokee and Crawford counties came the development of similar mines in the vicinity of Fort Scott, where a bed of coal from fourteen to twenty inches in thickness is found immediately under a heavy limestone. As it outcrops along the hillsides for miles to the north and south of Fort Scott, it furnished an easily accessible supply of good fuel for local consumption, and to a limited extent for outside shipments. In early days these mines were operated by individual farmers on whose land outcroppings of the coal were found, or by small companies which worked the mines during the winter, when labor was cheap and fuel in demand. This process was continued until recently, when the price of coal became so low that profitable mining is now carried on in but few places in the vicinity of Fort Scott—only such localities as chance to afford the coal with the minimum amount of stripping.

Further north, in the vicinity of Pleasanton and Mound City, similar coal-beds exist, and were discovered decades ago and operated on a small scale, the market conditions being such that those desiring coal could not well obtain it from outside sources, and therefore the local market was good and mining to a limited extent was a profitable occupation. So it was with the mines in Franklin county, in Osage

county, and in Leavenworth county, only in the latter place the mining is conducted by sinking deep shafts, the majority of them reaching about 800 feet below the surface.

Present Mining Localities.

At present coal is mined to a greater or less extent in about twenty counties, as follows, with a slight variation in number from year to year:

Atchison,	Cloud,	Franklin,	Montgomery,
Bourbon,	Coffey,	Labette,	Neosho,
Brown,	Crawford,	Leavenworth,	Osage,
Chautauqua,	Douglas,	Linn,	Shawnee,
Cherokee,	Elk,	Lyon,	Wilson.

The counties named in the western part of the state produce a brown coal which is quite inferior in quality to that obtained from the eastern part of the state, but which has a particular value on account of the high price of coal in central and western Kansas. Excepting these, the following is a brief summary of the character and location of the coal of the several counties:

Atchison.— About two miles south of the city of Atchison. The vein has an average thickness of fifteen inches. Mining operations began in 1893.

Bourbon.— The mines are principally operated to the southeast, east, and northeast of Fort Scott, and the coal is known in the market as the "Fort Scott red."

Brown.— Mine on Roy's creek, in the northeast part of county, near White Cloud, in Doniphan county. The vein is about sixteen inches thick, and quality of coal good. Operated for local trade.

Chautauqua.—Mines located near Leeds, in the northwest part of the county. The operations are principally conducted to supply the local trade. The vein is from twelve to eighteen inches thick, and therefore will not admit of operations for the general market.

Cherokee.—This is the second heaviest producing county in the state. The principal mines are located in the environs of Weir City, Cherokee, and to the southwest, where three different veins are operated, and further to the southeast, in the vicinity of Columbus, Crestline, and Tehama, where a fourteen-inch vein is operated for local consumption. At least four different veins of coal are operated in the county.

Coffey.—Mines located in the vicinity of Lebo. The coal is fourteen inches thick and operated for local trade.

Crawford.—This is the heaviest producing county in the state. The mines are situated around Pittsburg and to the northeast and southwest. Two veins are usually operated, and in some places three.

Douglas.—Mining operations almost abandoned. Mines located in the vicinity of Sibley and Blue Mound. The coal-vein is from twelve to eighteen inches thick, of fair quality, and formerly supplied a considerable local demand, but has been driven out of the market by cheaper coal, shipped in from Leavenworth and other places.

Elk.—Small quantities of coal have been found near Grenola, which have been mined to a limited extent for the local trade.

Franklin.— Coal of a good quality and, apparently, in great quantity, exists in different localities to the west and southwest of Ottawa. It is mined principally near Ransomville and Pomona, and supplies the country trade; is extensively teamed to Ottawa, and limited quantities are shipped into the general market.

Labette.— The coal is found in the vicinity of Oswego, and to the north. It is in veins about fifteen inches thick, and is mined by the "strip-pit" method to supply the local market.

Leavenworth.—A twenty-two-inch vein of coal is mined in and about Leavenworth city by shafting to a depth of between 700 and 800 feet. This county ranks third in the per cent. of its output.

Linn.— The coal in this county is obtained from Pleasanton, Boicourt, La Cygne, Mound City, and a few other places, usually by shafting, but sometimes by the "strip-pit" method. The county ranks fifth in output for the state.

Lyon.—Years ago small deposits of coal were found in the east part of the county which were operated for the local trade. Recently, however, the operations have been abandoned.

Montgomery.— Considerable coal exists in this county to the southeast of Independence, and also to the northeast towards Neodesha. It is mined only locally, and the cheaper fuel from the larger mines has almost put a stop to this.

Neosho.—Thayer is the center of the coal-mining district in this county. The mines are principally located to the west, near the border of the county. The coal-vein is from fifteen to twenty inches thick, and large quantities are obtained for Thayer and surrounding towns, and for the country trade.

Osage.—Coal is mined at many points along the Atchison, Topeka & Santa Fe railway between Topeka and Emporia, with Carbondale, Scranton, Burlingame, and Osage City the principal mining centers.

The mines are operated by both the "strip-pit" and the shafting methods. This county stands fourth in per cent. of output.

Shawnee.—The mines are located just west of Topeka and at Silver Lake and Dover. Mining is done by both shafting and drifting. The coal-veins average about thirteen inches in thickness.

Wilson.—The coal is situated to the southeast, east and northeast of Neodesha. The mines are operated quite extensively for local trade. The veins vary from twelve to eighteen inches in thickness, and furnish coal which is placed upon the market at almost as low rates as anywhere in the state.

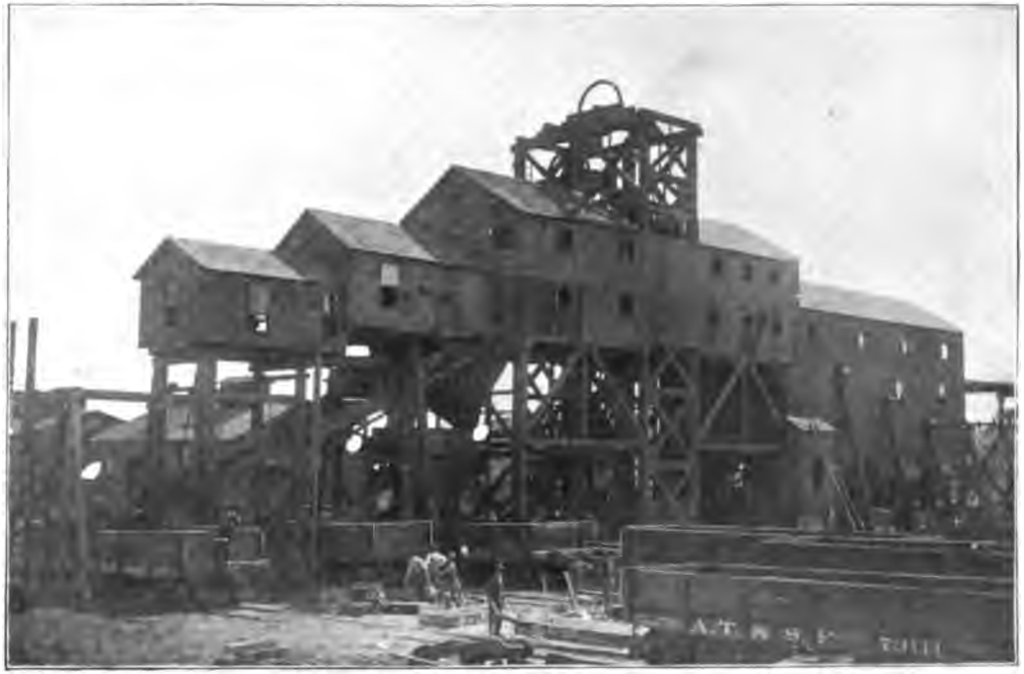
Chemical and Physical Properties of Kansas Coal.

The coals of Kansas are all bituminous or soft coals. Those in the southeast part of the state are the most valuable per ton for all purposes. Table XI (page 41), which is an abridgment and combination of tables prepared by Mr. Crane for the forthcoming report on coal, shows the average chemical and physical properties for the various Kansas coals.

Statistics on Value and Output.

Coal is the greatest Kansas mining product. The value of the coal output has reached many millions of dollars. For years it amounted to from three and one-fourth to four million dollars per annum. As the price has gradually decreased the output has correspondingly increased, so that the total value at the mines has remained surprisingly constant. It is difficult to surmise what would have been the result to the citizens of our state had coal-mining never been followed within our borders. The figures given in the accompanying tables to show the total value of output from year to year are very different from the figures which would have been compiled to show the money sent out of the state to purchase fuel had it been necessary to import all of our coal. Aside from this we have various industries, particularly our zinc-smelting and salt-making industries, which probably never would have been in operation had not our mines yielded such large amounts of good and cheap fuel. This is certainly true of our zinc-smelting industries. There is no place in the state showing greater activity than the coal-mining areas in the southeast. Railroads have been built to a wonderful extent, villages have sprung up, and the population has increased, making a great business for the merchant and the mechanic, for the farmer and gardener and small-fruit grower, so that the direct benefits of mining, therefore, reach out to all classes of citizens and in the aggregate produce many mil-

Cherokee-Lanyon Zinc Smelters, Weir City.



Coal Shaft at Chicopee.

TABLE XI.—SHOWING CHEMICAL AND PHYSICAL PROPERTIES OF KANSAS COALS.

Name of mining company.	Location.	Moisture in coal	Volatile and combustible matter	Fixed carbon	Total sulphur	Fixed sulphur	Volatile sulphur	Iron as Fe_2O_3	Iron as Fe	Specific gravity	Ash	Phosphorus	Pounds of water evaporated at 100°C. per pound of coal	Heat units (calories) with constant amount of coal
Missouri, Kansas & Texas	Mineral City	2.15	32.42	58.38	1.007	0.245	0.752	5.011	3.5077	1.338	7.05	Trace.	13.55	6336.6
Fidelity Land and Improvem't Co.,	Cherokee	1.96	40.62	53.30	1.460	0.235	1.225	....	....	1.284	5.12	"	15.45	7303.2
Columbus Coal Company	Stepville	2.13	36.71	57.55	0.684	0.210	0.474	5.001	3.5087	1.278	3.61	"	15.30	7142.1
Central Coal and Coke Company	Scammon	3.03	33.77	57.4[illegible]	1.894	0.549	1.345	....	....	1.322	5.72	"	14.35	6712.5
Kansas & Texas, No. 47	Weir City	3.16	39.21	53.87	0.765	0.428	0.337	....	....	1.281	3.76	"	14.26	6658.8
Western Coal Company, No. 2	Fleming	2.75	34.22	57.22	0.994	0.423	0.471	....	....	1.286	5.79	"	13.60	6390.3
Central Coal and Coke Co., No. 5	Weir City	3.14	34.87	55.39	2.557	0.385	2.172	....	....	1.343	6.60	"	13.22	6175.5
Santa Fe mine	Chicopee	3.17	34.83	55.10	1.381	0.209	1.172	4.234	2.964	1.382	6.90	"	13.45	6282.9
Santa Fe mine	Frontenac	3.06	35.92	54.89	2.329	0.358	1.971	....	....	1.337	6.13	"	13.00	6068.1
Kansas & Texas, No. 20	Pittsburg	3.32	34.57	57.08	1.867	0.318	1.549	....	....	1.310	5.03	"	13.45	6282.9
Pittsburg & Midway Coal Co., No. 4,	Midway	2.44	33.64	56.83	3.061	0.543	2.518	4.380	3.066	1.313	7.09	"	12.88	6014.4
Morganville Coal Company	Morganville, Mo.,	2.93	31.99	59.43	0.942	0.209	0.733	....	....	1.261	5.65	"	13.45	6282.9
Company unknown	Pleasanton	4.99	36.65	54.23	0.956	0.261	0.695	2.044	1.431	1.352	4.13	"	12.42	5799.6
State mine	Lansing	6.58	33.52	33.91	1.197	0.368	0.829	....	....	1.319	15.99	"	11.27	5322.6
Blacksmith mine	Blacksmith	13.42	39.83	39.29	5.550	1.136	4.414	....	....	....	7.46	"	....	....
Crane's mine	Dover	9.50	31.72	21.51	1.108	0.244	0.864	3.436	2.405	....	37.27	"	....	....
Anthracite taken from seam next to "Bell"	Leavenworth	0.82	9.14	89.03	....	....	....	....	....	1.400	1.01	"	....	....

lions of dollars of business which otherwise could not exist. The following statistical tables show, as best can be gathered, the total output and total value of the Kansas coals :

TABLE XII.

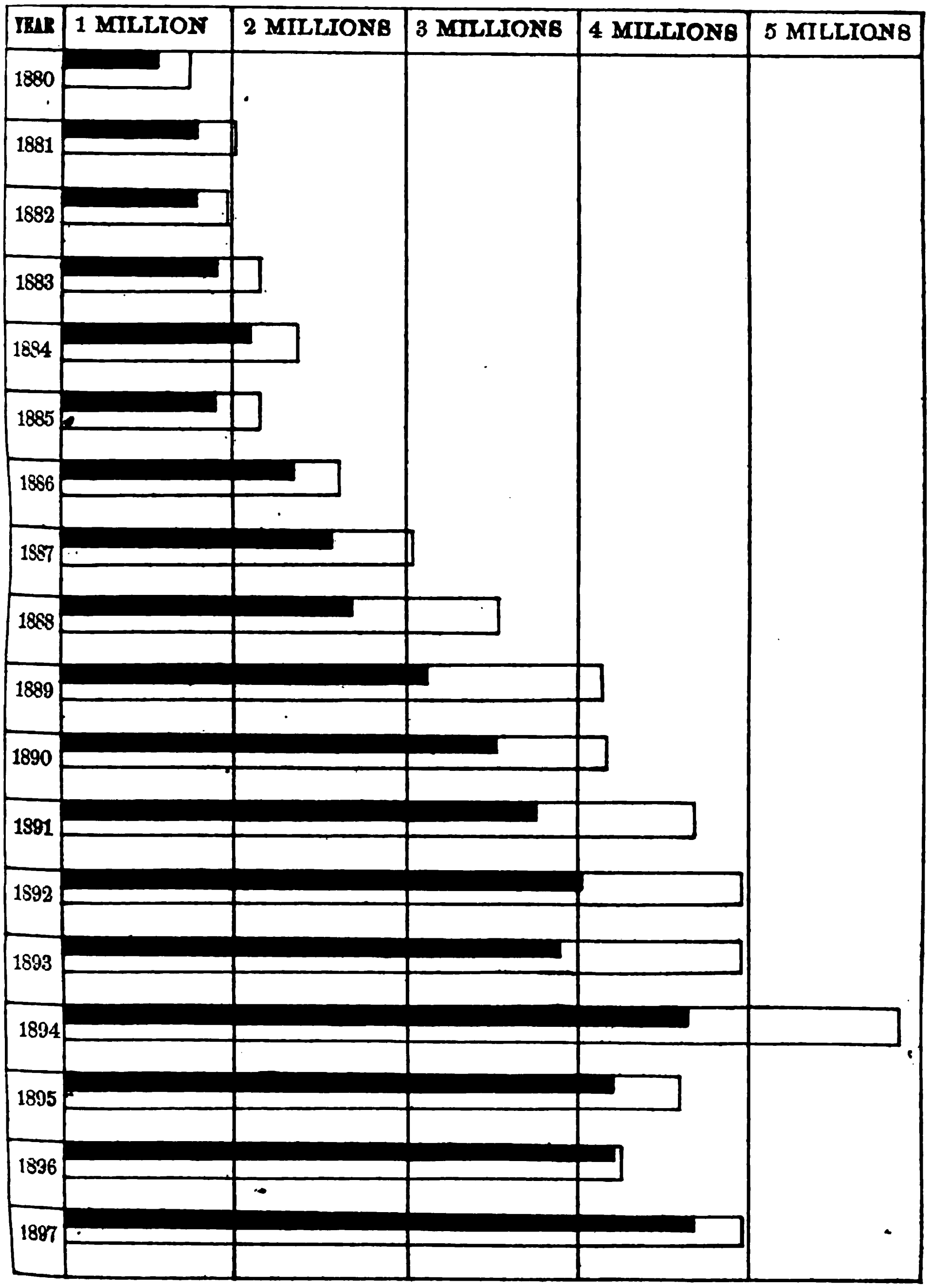
SHOWING COAL PRODUCTION IN SHORT TONS, FROM 1880 TO 1897, INCLUSIVE.

With price per ton and value of yearly product.

Year.	Production in short tons (2,000 pounds).	Price per ton.	Value of yearly product.
1880*	550,000	$1 30	$715,000
1881*	750,000	1 35	1,012,300
1882*	750,000	1 30	975,000
1883*	900,000	1 28	1,152,000
1884*	1,100,000	1 25	1,375,000
1885	1,440,057	1 23	1,770,270
1886	1,350,000	1 20	1,620,000
1887	1,570,079	1 40	2,198,110
1888	1,700,000	1 50	2,550,000
1889	2,112,166	1 48	3,126,005
1890	2,516,054	1 30	3,170,870
1891	2,753,722	1 31	3,607,375
1892*	3,007,276	1 31½	3,954,568
1893	2,881,931	1 37⅜	3,960,331
1894	3,611,214	1 35¾	4,899,774
1895	3,190,843	1 12½	3,590,141
1896	3,191,748	1 01⅛	3,227,357
1897	3,672,195	1 07	3,931,707
Totals	37,047,285	....	$46,835,808
Output previous to 1880	3,000,000	$1 50	4,500,000
Grand totals	40,047,285	....	$51,335,808

* Figures for 1880 to 1884, inclusive, and for 1892 taken from United States Geological Survey Reports. All others taken from Reports of State Inspector of Coal Mines.

PLATE II.



Annual output and value of coal from 1880 to 1897, inclusive.

The output is represented by the solid black, and value by the open spaces.

IV.—OIL AND GAS.

KANSAS is fast becoming an important factor in the production of oil, and is gaining notoriety as a producer of natural gas. The history of the discovery and development of these products within our state is a long and interesting one, but which can only be hinted at here. The following brief description is copied from volume I, University Geological Survey of Kansas:

History of Development.

The history of the discovery and development of oil and gas in Kansas may be divided into three parts: *First*, dealing with those indications which led up to further development. *Second*, with what may be termed the first stage of development. *Third*, the recent period of development, which continues to the present time.

First.—In a number of different places in the state the earliest settlers learned from Indians that oil springs existed. Some of them were counted of wonderful efficacy by the Indians, and were regularly visited by them for the purpose of obtaining material to be used by the medicine men in their various form of "practice." They were principally located in Miami and Wyandotte counties, and, possibly, some were known outside. The first settlers naturally became much interested in such occurrences, particularly as this was a period during which the development of oil in the Pennsylvania region was progressing so rapidly. Wells drilled in the vicinity of Wyandotte furnished considerable quantities of gas, a product at that time almost entirely unknown in America. As early as 1860, Mr. G. W. Brown, of Paola, began prospecting for oil, but the work was soon abandoned on account of the political difficulties which arose. In the vicinity of Mound City a few wells were drilled about the same time, each of which produced a small quantity of both oil and gas, but nothing considered of any special importance. In the early days after the war the citizens of Paola, principally through the efforts of Hon. W. R. Wagstaff, W. T. Shively and others, engaged the services of Prof. G. C. Swallow, then state geologist for Kansas, to make a survey of Miami county with special reference to the probability of finding oil. His report, a pamphlet of twenty-four printed pages, was full of encouragement, as may be shown by the following short quo-

tation: "The facts seem sufficient to convince any one familiar with indications of the development of petroleum in the productive regions of the country that it exists in large quantities in this county." With such encouragement as this companies were formed, and considerable prospecting done in the environs of Paola, but with indifferent success.

The surface indications of petroleum were too wide-spread in character to be confined to the limits of the counties named. As far south as Cherokee county considerable attention was given to the subject by the early settlers immediately after the close of the war. The prominence of the indications in the western part of the county may be judged from the fact that a small stream was named "Tar creek," and the current belief was that should prospecting be done vast quantities of oil would be obtained.

It will thus be seen that from the earliest days of Kansas history there has been a popular and wide-spread faith in the ultimate development of a great oil and gas industry in the eastern part of the state.

Second.—The second part of our history may include the time from about 1871 or 1872 to 1890. During this period a great deal of drilling was done in different places, principally by local companies and by drillers of limited experience. Paola was looked upon as the central portion of the oil and gas territory. In 1882 prospecting was again renewed in Miami county, and gas was found in the wells which were drilled about seven miles to the northeast of Paola, a locality to which the prospector had been drawn on account of the traces of oil which were found on the spring-waters at that particular place. The result of this prospecting was that sufficient quantities of gas were found to be piped to the city and introduced as a source of light and heat in the residence and business houses of Paola. Prospecting was continued all around the city, east, north, and west, so that practically as large a supply of gas as could be consumed was obtained, and has been maintained to the present time. Some of the wells produce considerable quantities of oil. One of these, for example, yielded fifteen barrels per day for quite a while.

Drilling was prosecuted in Wyandotte county quite irregularly during this second period. Sometimes it was interrupted by litigation; sometimes by discouragement from partial failures in obtaining gas; and sometimes from other causes.

In 1873 a well was drilled at Iola, the "Acres well," which produced sufficient gas to attract considerable attention and which was doubtless a factor in encouraging prospecting in other localities. The prospecting was rapidly extended to the different counties through-

out the whole southeastern part of the state, so that up to 1890 no less than a dozen towns and cities were principally or wholly supplied with both light and fuel for all domestic purposes.

Third.—The third period of history begins with the introduction of eastern money and eastern companies into our oil and gas territory. Having been attracted by the fair success obtained by the local companies, as above outlined, it was an easy matter for those who began it to induce companies of experience and means to come to Kansas and engage in prospecting for both oil and gas. Of these the companies which have done the most are the Guffey & Galey Company, of Pittsburg, and the Forest Oil Company, which has recently bought their interests; and the Palmer Oil Company, of Cleveland, Ohio, which has likewise obtained leases over large areas, and has conducted prospecting in a vigorous manner. Other eastern companies have also entered the field and have secured leases on a large number of farms, and are making arrangements to begin development at an early day. The territory which has been most productive during the recent period is located further to the southwest, with Neodesha and Thayer in its center.

Geographic Extent.

The area throughout which oil and gas have been found in greater or less quantities covers about 8500 square miles, and is located in the southeast part of the state. It may be approximately bounded as follows: From Kansas City draw a line to Lawrence, a distance of forty miles; from Lawrence pass a sinuous line to Sedan, in Chautauqua county. The portion of the state included between these two lines may all be considered as oil and gas territory, except a small area in the extreme southeastern part covered by the Cherokee shales. This is not more than 500 square miles in extent, and may be approximately limited by passing a line from the southwest part of Cherokee county to the middle of the east side of Crawford county, about ten miles north of Pittsburg.

There is not a single county within the limits above mentioned which has not produced either oil or gas, or both. To the northwest of the area a few wells have been drilled, with indifferent success, but prospecting has not been carried to a sufficiently great extent to warrant any one in deciding that gas could not be obtained over a much larger area to the northwest.

Geology of Oil and Gas.

Thus far in the history of development, the total production of both oil and gas has come from the Coal Measure formations. A number of wells have been sunk through these into the Mississippian lime-

stone below, but in no instance have any valuable results been obtained. Both shale and sandstone are productive, the latter being most abundantly so. In numerous cases, however, good flows have been obtained from the shale. It is common here, as well as elsewhere, to speak of the oil-sands or gas-sands. From the conditions of stratification already explained in the early chapters of volume I, University Geological Survey of Kansas, it will be seen that the occurrence of sandstone is somewhat irregular. Perhaps no well can be drilled which will not pass through an abundance of sandstone, so far as quantity of that material is concerned.

The sands are located in each of the great shale beds from the Cherokee shales upward. Those in the Cherokee shales are the most productive. In fact, it may well be stated that in the southeastern area nine-tenths of all the oil and gas have been obtained from the sandstones within the Cherokee shales, yet it is also true that each individual shale bed above this has produced one or the other of these materials. The gas-wells at Independence, east of the Verdigris river, for example, obtained all of their oil above the Oswego limestone. The drill penetrated the Cherokee shales, from which their supply of gas is obtained. At Cherryvale gas is largely obtained from the Cherokee shales, but a few of their most productive wells stopped within the upper shale beds. At Coffeyville the gas is obtained in some instances from the Cherokee shales, and in others from the shale beds above. At Neodesha, Thayer, and Iola, the Cherokee shales have been reached in almost every instance before any considerable flow of gas was obtained. The strong wells at Neodesha, and the recent very remarkable well drilled at Iola by the Palmer Oil Company — a well producing seven million cubic feet of gas per day — all were sunk nearly to the base of the Cherokee shales before the heavy flows were obtained. At Paola, the productive wells are quite shallow generally, but, as will be seen by referring to plate II, volume I, University Geological Survey of Kansas, the Cherokee shales are wonderfully thickened here, so that the wells reached their upper surface. This is also true at Osawatomie, at which place the wells usually were drilled to a depth of from 400 to 900 feet. A good illustration of the production of gas by one of the thin shale seams was met with during the drilling at Fulton. One of the wells was started at a place where there was an unusually heavy covering of soil and clay. At a depth of about forty feet below the surface the thin shale bed lying between the two Oswego limestones was reached, when quite a perceptible flow of gas was obtained.

It will thus be seen that both oil and gas are obtained from included sandstone, or the shale itself, within each of the shale beds

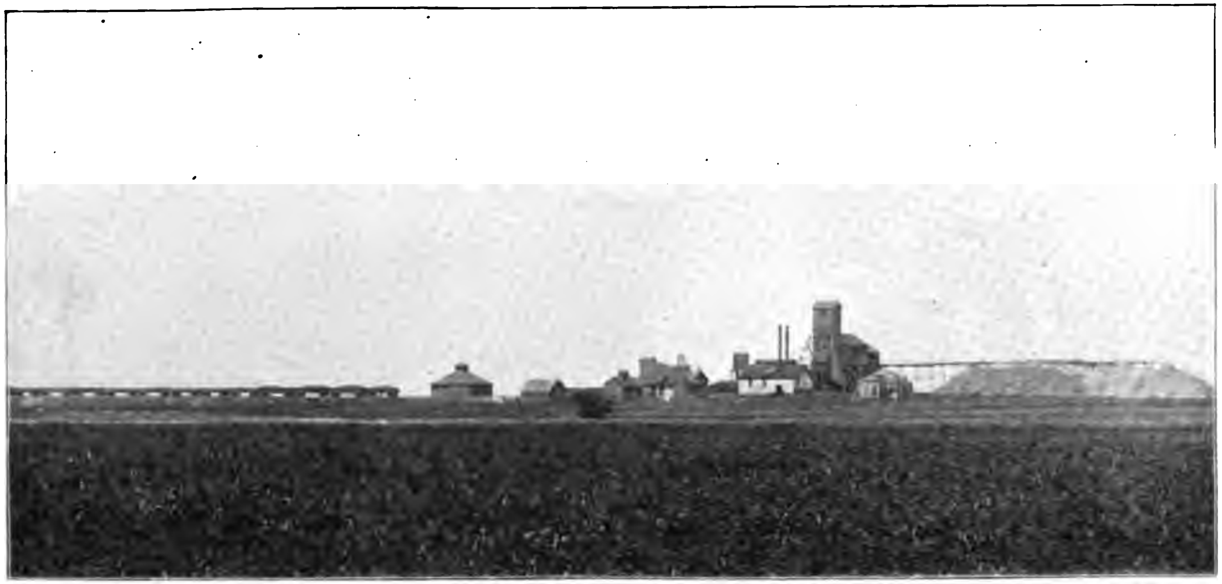
from the Mississippian upwards to the Lane shales. It is unnecessary here to speak of the geologic positions, the thickness, or the character of these different shale beds, as such have been given in the earlier chapters of the geological report already mentioned.

RELATION OF DEPTH TO PRODUCTION.

It will be seen from the foregoing that the depth at which oil and gas are obtained are dependent upon a number of factors. Where a productive shale bed comes to the surface the leakage has doubtless exhausted the supply long ago; but where it is sufficiently protected to prevent leakage the production will be shallower as the covering is lighter. The relatively barren area in Cherokee county presumably has been eroded to such an extent that the necessary covering has been removed from the Cherokee shales, so that whatever quantity of either oil or gas may have existed there at one time has been principally dissipated through surface leakages. This idea is strengthened by the frequent discovery of small quantities of gas in the ordinary prospecting for coal, and further by the indications of oil along Tar creek and other places. This principle may be extended to other portions of the country.

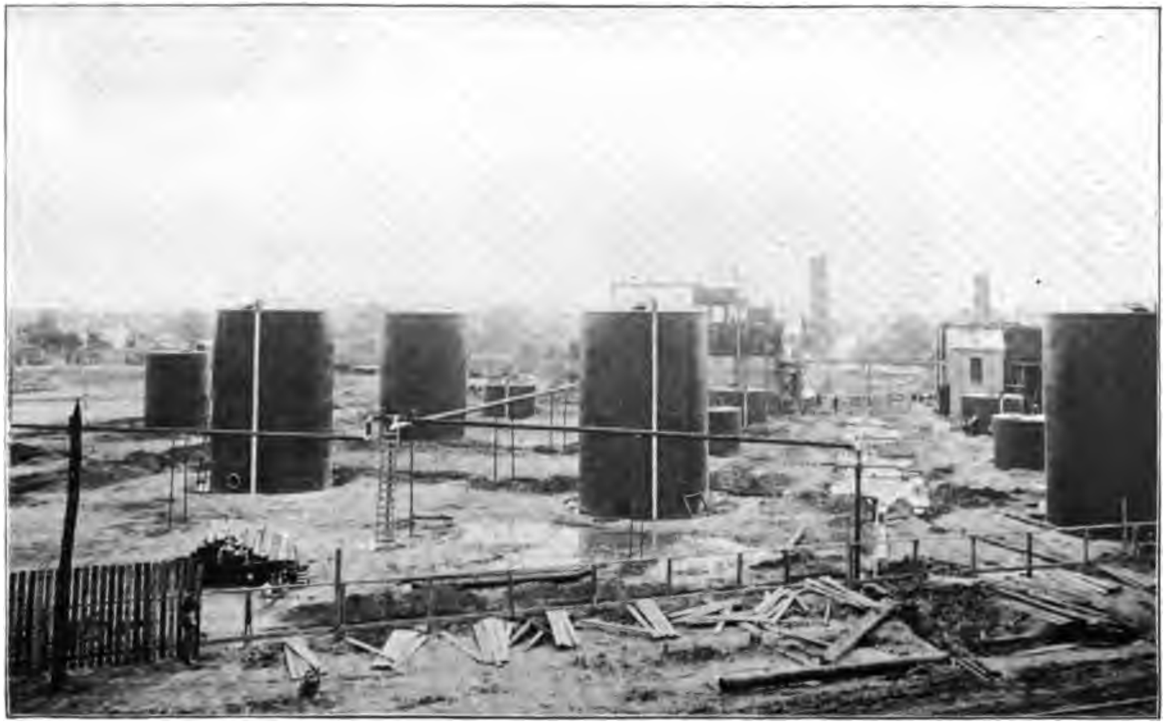
Every shale bed comes to the surface along its eastern limits, and consequently is deprived of a protective covering over portions of its area. No instance is known of any considerable quantities of gas being found in those localities, yet numerous cases have been reported of variable amounts of gas escaping from ordinary wells dug to depths of from thirty to eighty feet. Such escapes represent the natural leakage that is taking place over all surfaces which are not protected sufficiently from above. The question, therefore, of the depth at which gas may be reached is one which can be answered only conditionally for any particular locality. It will depend upon the depth below the surface at which gas-producing shale beds may be reached. A correct idea of this may be gained by a study of the different charts accompanying volume I, University Geological Survey of Kansas, which accurately represent the underground positions of the various shale beds in the southeast part of thestate.

Another factor, however, should be here considered: The great prevalence of salt water throughout the whole gas area may so seriously interfere with the flow of gas that a well which otherwise would be productive is almost entirely barren. When a well has reached a depth of 1000 feet, should gas be obtained in considerable quantities, the presence of large quantities of water would render the well useless unless the gas pressure were sufficient to lift the column of water the full height of the depth of the well. It is, therefore, quite probable that could a well be carried to a little greater depth after

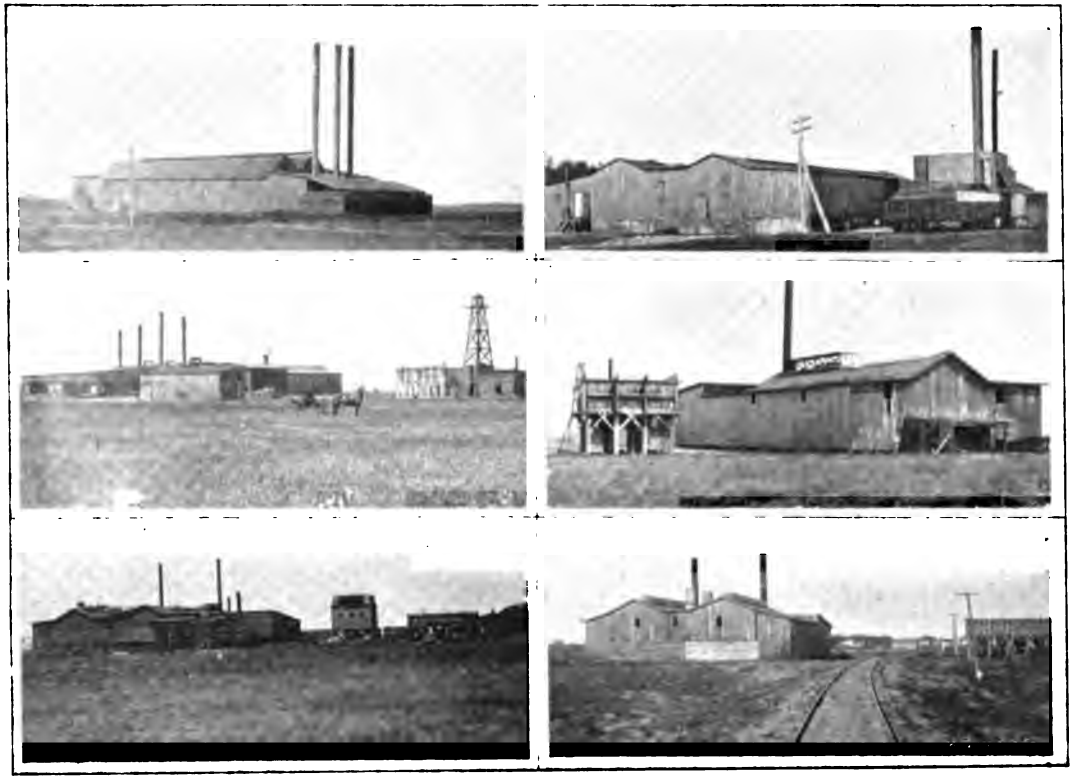


Coal Shaft at Fleming.

The Oliver Oil Well, Neodesha.



Tank Yard at Oil Refinery, Neodesha.



Group of Salt Plants, Hutchinson.

salt water is reached paying quantities of gas could be obtained were it not for the interference of the salt water. But few paying wells are known which are more than 900 feet deep, while many good wells are less than 600 feet.

IS THE MISSISSIPPIAN SERIES OIL OR GAS PRODUCING?

Little encouragement can be found for penetrating the Mississippian formation in search of oil or gas, although they pass westward under the Coal Measures. The more prominent reasons for this belief may be summarized as follows:

First, The extensive mining operations in southwest Missouri and southeast Kansas have failed to develop even traces of either oil or gas, excepting small quantities of an almost solid bitumen which occasionally is found in little pockets and crevices in the ore-bearing rocks. Had the Kansas hydrocarbons been generated below this horizon and driven through it to their present resting-place it seems exceedingly probable that greater indications of it would be met with in the mining operations.

Second, At different places, notably Pittsburg and Girard, wells have been drilled several hundred feet below the base of the Cherokee shales, searching for artesian water. At Pittsburg five such wells have been drilled, the deepest of which went over 1000 feet below the Cherokee shales. Neither salt water, oil nor gas was found in any of them, the water obtained being used as a supply for the city. Pittsburg is situated near the top of an underground ridge in the surface of the Mississippian rocks, which probably is an anticlinal ridge. Should gas ever have passed from below upwards through this heavy limestone some of it would certainly have lodged beneath this anticlinal and the Pittsburg wells would have discovered it. The Girard well was similar, but taken to a less depth. It started in the soil covering the Oswego limestone and went 357 feet below the base of the Cherokee shales. It found considerable gas within the Cherokee shales but none below them.

This is a question of great practical importance. It is evident that if the oil and gas were generated within the Coal Measures the leakage where their covering is thin has been so great that nothing more than mere traces could be expected within them. Should they have come from below, however, there may be accumulations of them below the Mississippian limestone which could be obtained by deep drilling. For the reasons above given such prospecting should be discouraged.

RELATION OF OIL AND GAS PRODUCTION TO ANTICLINALS AND SYNCLINALS.

The details of the exact number and locations of the various anticlinals and synclinals in the oil and gas territory are so little known

that it would be premature to draw any conclusions at the present time regarding the flow of oil or gas to those structures. The general dip of all the formations is towards the west and northwest, but along with this there are many reversals of directions, and anticlinals and synclinals trending in different directions. The indications are that such irregularities in the surface are too limited in extent and in angle of inclination to have any considerable influence on the accumulation of either oil or gas. If a given limestone has a slight irregularity of position due to the uneven surface of the ocean bottom on which it is deposited the formations beneath it might not partake of such irregularities. In such cases it is difficult to understand how its particular conditions of dip would have any bearing on the accumulation of gas below it. As was pointed out in chapter IX of volume I, University Geological Survey of Kansas, there is a total absence of conditions resulting from any particular orographic movements, and consequently a particular shale bed which is gas producing may have the stratifications within it entirely independent of the slight anticlinals and synclinals noticeable in the overlying limestone.*

By way of observation it may be said, that so far as has been determined there is a lack of harmony in the results obtained on this subject. Cherryvale is located on a slight anticlinal ridge, with an axis trending northwest and southeast which itself dips to the northwest. Whether this has any influence on the accumulation of gas at that place may well be doubted. At Neodesha all the strata seem to be dipping to the west about seventeen feet to the mile. It has not been ascertained whether or not there is here a slight anticlinal with axis pointing towards the northwest. Paola is in one of the greatest synclinal troughs there is in the state, yet large quantities of gas have been obtained from this synclinal trough.

It would seem that, so far as our present knowledge of the subject would indicate, there is little if any relation between the location of anticlinals and synclinals and the accumulation of either oil or gas.

Physical and Chemical Properties.

Until quite recently we have had but few data regarding the physical and chemical properties of the oils and gases of Kansas. The lubricating oils sold from Paola were partially examined and were found to possess superior properties for lubricants. Other companies have had samples tested at the refineries, and Prof. E. H. S. Bailey, of the chemical department of the State University, has made a large number of careful examinations of both oil and gas. His paper appeared in the report of the Kansas State Board of Agriculture, from which the following tables have been taken. The specific gravity of the oil was taken; then it was subjected to fractional distillations, and

the flash point and gravity for each distillate was determined. In the tables following, the left-hand column gives the range of temperature in the centigrade or Celsius scale at which the distillate was obtained, the second column the flash point of same, the third column the specific gravity, and the fourth column the amount distilled expressed in cubic centimeters. A glance at this column will show at what temperatures the larger portion of the oil was distilled, and, therefore, the general character of the oil.

TABLE XIII.

No. 1. MAIN WELL AT NEODESHA. G.—0.835.

Temperature, C.	Flash point, C.	Specific gravity.	Amount distilled.
40 to 110 degrees	Below 26 deg.	0.7058	61 c. c.
110 to 150 "	Below 26 "	0.7314	82 "
150 to 200 "	Below 26 "	0.7778	107 "
200 to 250 "	Below 76 "	0.8112	77 "
250 to 300 "	At 91 "	0.8377	101 "
300 "	Above 100 "	0.8691	215 "

About 14 per cent. of the original volume remained undistilled at the highest temperature to which it could be carried by a gas flame and in a gas flask.

TABLE XIV.

No. 2. KIMBALL WELL No. 2. NEODESHA. G.—0.835.

Temperature, C.	Flash point, C.	Specific gravity.	Amount distilled.
70 to 110 degrees	Below 30 deg.	0.7002	118 c. c.
110 to 150 "	Below 30 "	0.7417	178 "
150 to 200 "	Below 30 "	0.7793	157 "
200 to 250 "	At 57 "	0.8099	153 "
250 to 300 "	Above 95 "	0.8343	210 "
300 "	Above 95 "	0.8739	500 "

About 12 per cent. of the original amount remained undistilled.

No. 3.—HOPKINS'S WELL, five miles northwest of Neodesha. G.=nearly 1. Oil very heavy and hard to distill, less than half passing off below 300 degrees.

TABLE XV.

No. 4. ORDWAY WELL, THAYER. G.—0.849.

Temperature, C.	Flash point, C.	Specific gravity.	Amount distilled.
70 to 110 degrees	Below 27.0 deg.	0.7124	48 c. c.
110 to 150 "	Below 27.0 "	0.7374	82 "
150 to 200 "	Below 27.0 "	0.7742	70 "
200 to 250 "	At 69.5 "	0.8046	115 "
250 to 300 "	Above 95.0 "	0.8341	121 "
300 "	Above 95.0 "	0.8663	250 "

About 12 per cent. of the original amount did not distill.

These four wells may be looked upon as fairly expressive of the physical properties of Kansas oils. Possibly extremes may be found outside these limits, but not to any considerable extent.

The analyses of the gases showed that we have natural gas of most excellent quality when compared with the eastern gas. The following table gives the percentage composition of gas from six different localities, so that we may well conclude they well represent the gas of the state:

TABLE XVI.

SHOWING CHEMICAL COMPOSITION OF KANSAS NATURAL GAS.

Expressed in per cents.

Components of gas.	Paola.	Osawatomie.	Iola.	Cherryvale.	Coffeyville.	Independence.
Hydrogen, H	0.00	0.00	0.00	0.00	0.00	0.00
Oxygen, O	0.45	Trace.	0.45	0.22	0.12	Trace.
Nitrogen, N	2.34	0.69	7.76	5.94	2.21	3.28
Carbon monoxide, CO	1.57	1.33	1.23	1.16	0.91	0.33
Carbon dioxide, CO_2	0.33	0.22	0.90	0.22	0.00	0.44
Ethylene series, C_2H_4, etc.	0.11	0.22	0.00	0.00	0.35	0.67
Marsh gas, CH_4	95.20	97.63	89.66	92.46	96.41	95.28

The slight differences in above gases amount to but little. So far as they go, however, it will be seen that the Osawatomie gas has the largest per cent. of marsh gas, which is the principal combustible material, and the smallest per cent. of nitrogen, an inert substance, and therefore would be called the best gas.

Origin of Kansas Oil and Gas.

The evidence available from the various conditions under which they now exist points towards an organic origin for the Kansas oil and gas. Their intimate association with the shales, which are so rich in organic matter, would also imply that they are principally derived from vegetation, for our Coal Measure shales are poor in both vertebrate and invertebrate fossils, which indicates that animal life was not very abundant during the shale-forming periods of Coal Measure time. The bituminous character of the shales is therefore principally, or almost entirely, due to the presence of vegetable matter. The absence of oil in the Mississippian series, as already explained in this chapter, would strongly favor the idea that the Coal Measure shales are the formations in which the oil and gas were generated.

If the oil is obtained from the shales, it would consequently be of vegetable rather than animal origin. The chemical composition of the gas, as just given, also indicates the vegetable origin of the gas; for, were it of animal origin, it probably would have more nitrogen. Also, the oil lacks that peculiar fetid odor some oils have which is usually regarded as indicative of animal origin.

Its presence in the sandstone beds would by no means indicate that the sandstone formations were the sources from which it was generated, but rather, that the sandstones act as receptacles for the gas after it is generated. Their porous condition makes them, in reality, great underground cavities in which any liquid or gaseous substance may find a resting-place.

Probable Extent of Productive Territory.

The area over which oil or gas, or both, have already been obtained was outlined in the first pages of this chapter. It might be well to say a few words regarding the probability of the productive territory being extended to the west. It should be clearly understood at the outset that any remarks that may be made on this subject are only tentative. If our great shale beds pass to the west a considerable distance beyond the limits of the deep wells already bored, there is no reason for doubting their bituminous nature. All that we know regarding the conditions of deposition would imply that a considerable amount of organic matter was mixed with them at the time of their formation much farther to the west. This is believed because, as far west as prospecting has been carried, the carbonaceous nature of the shales seems to be maintained, with no indication of any considerable decrease. If such is the case, we cannot know of any reason why both oil and gas may not have been produced in the depths of the earth many miles west of the present known limit.

But this should not be used as a basis for hopes of a great productiveness very much farther west. A difficulty is encountered which probably will increase rapidly towards the west. I refer to the almost universal presence of salt water. Naturally, with the dip of our strata being as it is, the productive shales and sandstone lie much deeper to the west, and the difficulty produced by the salt water will rapidly increase. The mere fact that both gas and oil are lighter than water is of little avail in such case. The minute pores in the sandstone and the shales through which the gas must pass will be effectually stopped by the great pressure of the water.

Few questions are of more immediate importance to the western cities like Wichita and Hutchinson, than the question of the probability of obtaining oil or gas by boring. Could a few wells be sunk in these localities to the base of the Cherokee shales much light would be thrown upon the question thereby, and if accurate records were kept and placed in the hands of a competent geologist for comparison with the data contained in the reports of the University Geological Survey of Kansas, a much more valuable estimate could be made of the probabilities in the case. Such wells would have to be sunk

somewhere from 2000 to 3000 feet deep, and would therefore be very expensive, with the chances very great of the salt water preventing any valuable results, even though the gas and oil might possibly exist.

TABLE XVII.

SHOWING VALUE OF THE NATURAL GAS PRODUCED DURING 1897 IN EACH OF THE GAS FIELDS IN KANSAS.

Locality.	Value of product.	Locality.	Value of product.
Iola..............	$50,000	Neodesha	$12,500
Coffeyville	30.000	Osawatomie	10,000
Independence	20.000	Chanute	2,500
Cherryvale	15.000	Wyandotte	500
Paola	15,000	Total	$155,500

TABLE XVIII.

PRODUCTION OF PETROLEUM IN KANSAS FROM 1889 TO 1897, INCLUSIVE.

Figures from 1889 to 1896, inclusive, are taken from the Reports of the U. S. Geological Survey.

Year.*	Barrels.	Year.	Barrels.	Price per barrel.	Value.
1889......	500	1894.......	40,000	48 cts.	$19.200 00
1890......	1,200	1895.......	44.430	64 "	28.435 20
1891......	1,400	1896.......	113,571	63 "	71,549 73
1892......	....	1897.......	90,000	60 "	54 000 00
1893......	18,000	Totals...	*309,101	....	*$182.504 93

*Estimated value of product from 1889 to 1893 (21,100 barrels) is $9,320 (included in totals).

TABLE XIX.

VALUE OF NATURAL GAS PRODUCED IN KANSAS FROM 1889 TO 1897.

Figures for 1889 to 1896, inclusive, are taken from the Reports of the U. S. Geological Survey.

Year.	Value.	Year.	Value.
1889	$15,873	1894	$86,600
1890	12,000	1895	112.400
1891	5.500	1896	124.750
1892	40,795	1897	155.500
1893	50,000	Total	$603.418

V.—SALT.

THE Kansas salt beds are important not only to Kansas but to all the surrounding country. In 1888 when Kansas salt first entered the market it was worth $1.22 per barrel at the factory; in 1897 the average price for the same salt at the Kansas factories was but little more than thirty cents per barrel. This reduction in the price of salt has been gradual since 1888, although quite irregular. The citizens of Kansas and surrounding territory reap the benefit of this great decrease in price.

The United States is today using about fifteen million barrels of salt a year, of which Kansas produces eight and one-half per cent. So large a production in one locality, which only a few years ago produced nothing, has materially affected the salt trade all over America. It has supplied salt to our own state and to all neighboring states, thereby preventing shipment from the eastern mines into a large territory formerly supplied entirely from without. It has in this way not only decreased the price of salt in Kansas, Iowa, Missouri, and Texas, but at the same time has been an important factor in the reduction of salt prices everywhere else in America. The included tables show these conditions more clearly than can be given here.

Geography of Salt-Mining Area.

The exact limits of the salt deposits of Kansas are not known. At present, the only factories in operation are located in the vicinity of Hutchinson, and at Lyons and Kanopolis.

The first discovery of salt in Kansas was made at Wellington, where the beds were reached at a depth of 250 feet. The eastern limit of these particular deposits probably is not far from Wellington. The northern limit is not known, salt having been found as far north as any deep wells have been sunk in prospecting for it. From the general geologic conditions it is quite evident that salt exists under vast areas westward from where it is now mined. A conservative estimate would place the total area underlaid by it at not less than 15,000 square miles.

In addition to this, it must be conceded that the Coal Measure shales, farther to the east, could furnish a strong brine, sufficient to manufacture unlimited quantities of salt, were any one disposed to use this source. Such a factory was started at El Dorado, some years ago, the

operator pumping water from a deep well which brought the brine from the Coal Measure shales. With the price of salt as high as it was in 1888, and had been for decades previously, such manufacturing could be conducted at a profit.

Geology of Kansas Salt.

The salt beds of Hutchinson, Lyons, and Kanopolis are located in the Permian formation. The wells pass through the surface material, differing in thickness and character at different places, and then enter the Permian shales. At Lyons, at a depth of about 650 feet, the rock salt is first reached, from which point it is interbedded with shale for about 400 feet. Some of the salt layers are from 20 to 30 feet in thickness, while many others are very thin, often reaching only one-fourth of an inch. The interbedded shale likewise varies in thickness and in character. Throughout this 400 feet about two-thirds of the total thickness is salt, but it is difficult to find many of the salt layers exceeding 8 or 10 feet in thickness, and, even then the salt is not entirely free from sedimentary impurities.

At Lyons the company is working on the thickest layer they have found, which lies at a depth of 1000 feet. The layer is 26 feet in thickness and is comparatively pure, although irregularly distributed through it there is an occasional splash of shale impurities. Part of this same layer, however, is almost chemically pure, having yielded by analysis as high as 99.97 per cent. pure salt. The conditions at Kanopolis, Little River, Kingman, and elsewhere are similar to those at Lyons.

In the vicinity of Hutchinson, where the salt is dissolved underground, it is more difficult to determine the exact underground conditions, our knowledge being based wholly upon the records of the various wells which have been drilled into the salt beds. There are doubtless places here and there where the earthy impurities are less abundant and the layers of salt thicker, but as far as is known the general conditions for the whole area are about as thus given.

There is abundant evidence that during Permian time large bodies of ocean water were cut off from the main ocean and were evaporated almost to dryness, so that the salt was precipitated from the concentrated ocean brines. Throughout the same period, during the rainy seasons, various drainage channels carried earthy sediments down into the water, so that the sediments were spread out over the bottoms and intermixed with the salt.

Manufacturing Processes.

Two kinds of salt are sent into the market from the Kansas mines, rock salt and evaporated salt, Formerly rock salt was mined at three different localities, Kingman, Lyons, and Kanopolis. The Kingman

Solar Process Salt Factory, Solomon City.

The Best Bros.' Keen Cement Factory, Medicine Lodge.

mine has been abandoned for years, as the demand for rock salt was not sufficient to justify the operation of so many shafts. At present the same company owns the mines at Lyons and Kanopolis, and usually operates but one at a time. The shafts are made similar to coal shafts, or shafts in other mining localities. When the particular layer of salt is reached which it is desired to use it is quarried out in the same general manner as coal. The salt is undercut and wedged or blasted down, great rooms being opened with occasional pillars left to support the roof. The masses of rock salt are then hoisted to the surface, graded, and crushed to whatever degree of fineness is desired for the particular market to which it is sent.

In the manufacture of evaporated salt a hole is drilled to the salt beds and two pipes inserted. The outer pipe fits the opening of the well snugly so that water does not pass on the outside of the pipe. The inner pipe is smaller and allows water to pass between its outer wall and the inner wall of the larger pipe. One of these passes downward to the particular part of the salt beds to be dissolved, and the other one to near the bottom of the mine. Water is now forced down the shorter pipe and allowed to stand for some hours until it has dissolved enough salt to saturate it. The strong brine, being heavier than the fresh water, settles to the bottom of the opening made by the dissolving out of the salt. When pumps are applied to the shorter pipe the extra pressure exerted upon the water causes the strong brine from the bottom of the mine to be forced up through the longer pipe The rapidity with which the pumping is done will determine the strength of the brine, as the water must remain in contact with the salt a considerable time to become entirely saturated.

The strong brine is placed in vats or pans to be evaporated by artificial heat. The different companies operating at Hutchinson and vicinity have slightly different mechanical devices for effecting this evaporation and for getting rid of such impurities as the brine may hold, but the general operations are essentially the same. One company has a method of producing a partial vacuum, so that the evaporation takes place at a lower temperature than would otherwise occur; but the greater part of the salt made at Hutchinson is evaporated under the ordinary atmospheric pressure. Different companies are making a specialty of different grades of this evaporated salt.

Commercial Relations of Kansas Salt.

The territory reached by our Kansas salt is as extensive as the western half of the United States. The domestic consumption in Kansas, Arkansas, Missouri, and Iowa is largely supplied through our Kansas mines, while much of our salt reaches as far north as Minnesota and the Dakotas, and as far south as Texas. West from the

states mentioned nearly the whole of the salt used comes from Kansas, excepting that supplied by California, Utah, and Nevada, which, in the aggregate, amounts to but little over half a million barrels a year.

The following table embodies the total output of the Kansas mines, stated by years, during the whole period since their operations began. The average price per barrel was obtained by dividing the total value, as reported, by the total number of barrels.

TABLE XX.

KANSAS SALT PRODUCTION.

From United States Geological Survey Reports, excepting 1897.

Year.	Barrels.	Average price.	Value.
1888	155,000	$1.219	$189,000 00
1889	450,000	.45	202,500 00
1890	882,666	.45	397,199 00
1891	855,536	.357	304,775 00
1892	1,480,100	.523	773 989 00
1893	1,277,180	.369	471,543 00
1894	1,382,409	.383	529,392 00
1895	1,341,617	.36	483,701 00
1896	1,347,793	.31	519,475 00
1897 *	1,224,980	.34	417,626 94
Totals	10,397,281	....	$4,289,200 94

* Cooperage in 1897 is reported at about twenty-five cents a barrel, and in other years at proportional rates, which should be added to above totals to give a correct idea of the magnitude of the salt industry.

VI.—GYPSUM.

GYPSUM, the sulphate of calcium, has long been used in the manufacture of "plaster of paris." During recent years the application of the plaster of paris in plastering ordinary walls in buildings has been gradually extended, with a consequent increased demand for the plaster.

Plaster of paris hardens, or "sets," in so short a time that it is impossible to spread it on the wall in proper shape without treating it in some way to retard the setting process. The improvements of modern times have been largely along the line of the introduction of retarders in the setting process. With the difficulty of rapid setting overcome, there is opened up an ever-increasing demand for plaster of paris in ordinary plastering.

Walls plastered with this material have many superior qualities over those plastered with old-fashioned lime mortar. The room dries in a much shorter time, so that it can be occupied earlier; it admits of being covered with wall paper within twenty-four or forty-eight hours after the plaster is put on, while the common lime-mortar plaster will discolor the paper if applied much under six months' time; it is harder and cracks less easily and sets on the wall better, and in every way is more serviceable, and hence more desirable as a plastering material.

Fifteen years ago its use was hardly known for this particular purpose. The white plaster of Paris has been used for a coat of whiting or stucco covering the lime plaster for a much longer period; now, in the great Mississippi valley, it is used almost as much as the lime plaster, and probably will soon be used to a much greater extent than at present.

Kansas Gypsum.

Kansas has a large amount of gypsum from which the best hard-cement plaster can be made. The gypsum occurs in two somewhat different forms; one in the form of a rock, so that it is quarried similarly to other stone, and another in the form of small crystalline grains, producing a mass looking much like sand. The manufacturers of the plaster generally speak of this latter kind as "gypsum dirt," although in many places the quality of the material is sufficiently pure to hardly admit of the term "dirt."

Geographic Locations.—The localities in Kansas where gypsum exists may be summarized as follows: First, the northern area, in the vicinity of Blue Rapids, where the rock form of gypsum occurs in great abundance interstratified with the Permian shales and limestones. It is quarried and used in the manufacturing process by the following companies at Blue Rapids: Great Western Plaster Company, Fowler Brothers Cement Plaster Company, and Blue Valley Plaster Company.

To the southwest of Blue Rapids gypsum is found in a number of localities, but rarely in sufficiently large quantities to be mined to any great extent until the vicinity of Solomon is reached. Here the material occurs some distance beneath the surface, and is mined and manufactured by the Crown Plaster Company, of Solomon City. Quite recently this company has been consolidated with the Kansas Cement Plaster Company which has a factory at Hope where the rock gypsum is also mined by shafting to a depth of seventy to eighty feet. In the vicinity of Solomon and of Hope the gypsum is not so prominent as it is at Blue Rapids, but still it is known that large quantities of it could be obtained if there were sufficient demand for its products.

South and southwest from Hope gypsum is known in the vicinity of Peabody and Newton, and for many miles to the south. Farther west, in Barber county, it is found in great quantities. The rough hill country to the southwest of Medicine Lodge is covered with gypsum, which occupies a position on the hilltops similar to the way in which limestone and sandstone cover hilltops in other parts of the state. In some places it reaches from twenty to thirty feet in thickness and occupies an area of many square miles, producing in the aggregate an amount of material sufficient to supply the whole world with hard plaster for many years. At Medicine Lodge Best Brothers' manufactory is located, where a large amount of the material is manufactured into hard plaster.

The "gypsum dirt" material, above alluded to, is found in many places in the central area not far from Hope. It was first manufactured into plaster at Gypsum City, but later, deposits of it have been found in other places and manufactories have been widely established. The Salina Cement Company has two plants—one at Dillon, on the Missouri Pacific railway, in the southern part of Dickinson county, and one at Longford, which manufacture the "Agatite" brand. The Acme Cement Company formerly was operating two plants in Kansas, one at Gypsum City, but this has recently been abandoned, and a plant at Rhodes, in southern Dickinson county, which is still in successful operation. There is also a factory located in the country, about

half way between Rhodes and Dillon, which obtains its material from the loose gypsum, or gypsum dirt.

These five localities are the only ones which have thus far furnished this kind of material for the manufacture of hard plaster, but other places are known in the state where the same kind of deposits exist; in fact, it seems as though this kind of material is found in small quantities in many of the valleys of the little streams almost throughout the whole Permian area of central Kansas. A few of these new localities are known to have large quantities of the material, and are awaiting the investment of proper capital and enterprise for their development. It need not be surprising should other deposits be found as valuable as any thus far known.

Origin of the Gypsum Beds.

The origin and nature of formation of the rock gypsum is well understood. It has been produced by the evaporation of an inland body of ocean water. During Permian time it seems that a number of bodies of water were separated from the main ocean and were desiccated partially to dryness. By such a process the calcium sulphate of the ocean water was precipitated almost the first of any of the salts held in solution. As has already been stated under the description of "Salt," some of these bodies of water were carried to a high degree of concentration and produced large beds of salt. Others were evaporated sufficiently to form beds of gypsum, and then in some way the evaporation seems to have ceased, as none of the more soluble materials known to exist in all ocean water are found immediately associated with the gypsum beds. It is hardly probable that one great inland salt sea covered the whole of the territory from Blue Rapids to Barber county. In fact the Barber county gypsum was formed at a later date than the Blue Rapids gypsum. Geologically it is about a thousand feet higher than the Blue Rapids gypsum, and could not have been in any way connected directly with the same body of water which produced the Blue Rapids material. But from the nature of all the Permian rocks and the rocks of the Red Beds area it seems that the conditions remained much the same for a long time while a thousand feet of sediment was being deposited.

Detailed stratigraphic investigations have not yet been carried far enough to show whether or not there is any general relation between the salt beds and the gypsum beds.

The other deposits of gypsum, the so-called "dirt" deposits, are evidently much more recent in formation. Dr. G. P. Grimsley* has already advanced the idea that they have been deposited from spring

*Bulletin G. S. A., vol. VIII, p. 239.

waters which have become saturated with calcium sulphate by being brought into contact with the rock gypsum existing near by. This view is undoubtedly correct, with the possible exception that it may be unnecessary to insist that any perceptible body of rock gypsum is necessary, as all the Permian shales are more or less permeated with it. Water percolating through these shales would dissolve the gypsum particles and would deposit them the same as though water were saturated with gypsum from heavier beds. Doctor Grimsley succeeded in finding beds of rock gypsum adjacent to the loose gypsum deposits in a number of instances, but probably not in all. In either case it is quite probable such deposits are in the process of formation at the present time.

Manufacturing Processes.

The methods of manufacturing gypsum into the hard plaster are comparatively simple and easily accomplished. They consist, first, in quarrying the raw product; second, in preparing it for the calcining furnace; third, in calcining it to drive out the water; fourth, in mixing it with some kind of a retarder; and, fifth, in mixing it with hair or fiber to prepare it for mixing into mortar for immediate use.

The mining processes are varied, according to the requirements of the various localities. Best Brothers simply go to the tops of the hills, quarry it as so much stone, break it into fragments as may happen to be convenient, and send it to the factory. At Hope, a shaft is sunk to a depth of seventy-five to eighty feet, and the gypsum is undercut and broken down and hoisted, the same as rock salt or coal, and is then loaded onto a flat car and freighted to the factory, about a mile away. At Blue Rapids the gypsum outcrops along the bluffs of the Blue river and its tributaries. The common process of mining is that of tunneling, similar to the way coal is mined where it outcrops along a hillside. Here, also, it is loaded onto a flat car and freighted to the factory nearly a mile away by one of the companies, and is taken immediately to the factory by the other.

Upon reaching the factory in all of these cases the rock gypsum is crushed by first passing through an ordinary jaw crusher and later between rollers until it is ground to a fine powder. From here it is sent directly to the calcining kettles.

The loose gypsum or the dirt gypsum is taken up in a different manner. The surface soil is removed by a plow and scraper, after which ordinary disc harrows are employed to loosen the gypsum. The harrows are drawn over it in many directions, giving a loose, pulverized mass from four to six inches in depth. Teams with scrapers are then sent out to gather up the loose material, exactly similar to the way dirt and sand are gathered in ordinary road grading.

The calcining kettles generally used are all of about the same pattern. Imagine a circular tank standing on end, made of boiler iron and strongly riveted. Such a tank may be from eight to ten feet in diameter, with walls from five to seven feet in height. Through the middle part of this tank pass two horizontal wrought-iron tubes about ten inches in diameter, fastened to the sides the way flues are fastened into an ordinary boiler. In the bottom of this tank is an iron bottom which is convex upwards; the whole set in masonry so arranged that a fire may be built under the kettle, with the heat passing up around the sides almost to the top and through the two flues which pass through the tank or kettle. Now, imagine a rotating vertical shaft passing downwards into the kettle through its center, and having arms attached on every side, but at various heights along it, so that by a simple rotary motion these arms, some above and some below the flues, will constantly agitate the powdered gypsum in the kettle. Such, in brief, is the calcining kettle used universally in Kansas, and generally employed throughout America.

The gypsum, in a pulverized condition, is inserted in the kettle, the fires are built, and the temperature raised to a sufficient extent to drive off the water of crystallization. As the water escapes in the form of steam, the whole pulverized mass seems to boil like so much flour or dust with air driven through it. The length of time for heating a charge depends upon the way the temperature has been held, but usually from two to three hours are required. At the end of this time the calciner, by methods which are somewhat of a secret, determines that the calcining has been carried as far as is desirable, and thereupon discharges the whole mass into a bin of masonry. This discharge is effected by raising a small trap door provided at one side of the kettle so that the loose, powdered material runs out like so much flour would run from a bin.

Here two different lines of operation are employed, one by one factory and one by another. One method is to allow the hot calcined plaster to remain in the masonry bin until it has been cooled, so that it can be handled without danger of firing the buildings. The other is to remove it immediately through pipes to which suction is applied by means of a fan driven by machinery. If a sheet-iron pipe be lowered to the surface of the plaster and a strong current of air driven through the pipe, it will suck up the powdered plaster and carry it to whatever hight is desired, at the same time reducing the temperature so that it can be handled or bagged at once if desired. By such a process much time is saved and much heavy masonry store room avoided.

After the plaster has cooled it is removed to a proper room, where it is mixed with the retarder, should any be necessary, and later mixed with the hair or vegetable fiber, such as is used in common plastering, and lastly bagged and weighed and laid away in the storeroom ready for shipment.

A number of different kinks of retarders are used to prevent the rapid setting of the plaster. Some are claimed to be of secret composition, some are bought on the general market, some companies manufacture their own retarders, and a few of the manufacturers of the plaster from the dirt gypsum claim that no retarder whatever is necessary for their goods. In general it may be stated that organic matter, clay, and materials which are plastic or somewhat of the nature of glue, will serve for retarders. Most of the retarders are largely made from products obtained from the large packing-houses. The simple amount of clay and soil and other earthy materials existing in the dirt deposits may in some cases be of the right kind and quantity to avoid the necessity of the addition of any retarder whatever.

Commerce of Kansas Plasters.

Kansas cement plasters have finally made their way into almost all of the markets of America. They have traveled eastward to New York and Boston and westward to San Francisco. Occasionally shipments are made north and south to Minneapolis and New Orleans; but the greater part of the products of our factories are sold west of Ohio.

The freight on such goods soon amounts to as much as the first value of the goods themselves. Freighting west of the Mississippi, as every one knows, is more expensive per ton per mile than in the eastern part of America. During 1897 the common rates from Kansas to St. Louis were three dollars a ton, and to Chicago four dollars a ton. This is more than the manufacturers of the same class of goods in the state of New York paid to get their products laid down in either St. Louis or Chicago. Still, in the face of these difficulties, the superior quality of the Kansas products permitted them to compete favorably in some of the eastern markets with materials manufactured much nearer the point of consumption.

The following table gives the approximate output and value of hard plaster from our Kansas mines for 1897, and for preceding years.

Agatite Plaster Factory, Dillon.

The Great Western Hard Plaster Factory, Blue Rapids.

TABLE XXI.

SHOWING AMOUNT AND VALUE OF GYPSUM PRODUCED IN KANSAS FROM 1889 TO 1897.

Year.	Output in tons (2000 pounds).	Average price per ton.	Value of output.
1889	17,332	$5 44	$94,235
1890	20,250	3 58	72,457
1891	40,217	4 01	161,322
1892	41,016	4 76	195,197
1893	43,631	4 16	181,599
1894	64,889	4 65	301,884
1895	72,947	3 74	272,531
1896	49,435	3 00	148,371
1897	50,045	5 05	252,811
Totals......	399,762	....	$1,680,407

Figures from 1889 to 1896, inclusive, are taken from the Reports of the United States Geological Survey.

VII.—HYDRAULIC CEMENT.

THUS far in our history Kansas has produced hydraulic cement in considerable quantity in only one place—Fort Scott. Here two factories are in successful operation, and are producing a high grade of hydraulic cement at the rate of about 160,000 barrels per year. It is made from an impure limestone—the cement rock of Swallow, or the lower member of the Oswego limestone system, as designated in our University Geological Survey.

This limestone is peculiar in character, having in most places but a single layer, being exceedingly compact in texture, fine in grain, with a conchoidal fracture, and dark in color for a limestone. Its chemical composition, as determined by a series of analyses just completed in the chemical department of the University, is as follows. Other samples have been analyzed by other parties, the results of which are also given.

Historical Sketch.

A brief historical sketch of the hydraulic-cement industry of Kansas was kindly furnished by Mr. C. A Brockett, president of the C. A. Brockett Cement Company, at Kansas City, and is as follows:

"Hydraulic-cement rock was first discovered at Fort Scott in 1867, by A. H. Bourne. Samples of rock were sent to Prof. Louis Agassiz of Harvard University, Cambridge, Mass., which elicited the following reply:

HARVARD UNIVERSITY,
Cambridge, Mass., April 17, 1868.

Your curios specimens are received, and are a valuable acquisition to our cabinet of minerals, for which please accept our thanks. The rock, if properly calcined, will make a very superior quality of hydraulic cement, and, I hope, a fortune to you. Yours thankfully, LOUIS AGASSIZ.

"Small works for the manufacture of hydraulic cement were built in 1868, and were known as the Fort Scott Cement Works. In 1869, C. F. Drake and Dr. B. F. Hepler associated themselves with the company in the manufacture of the cement. In the fall of 1869 they had invested $4000 in the works, which had a capacity of producing ten barrels of cement per day. The price of Louisville cement in that market at that time was ten dollars per barrel. The Fort Scott Cement Company put their price down to five dollars per barrel. The

TABLE XXII.—ANALYSES OF CEMENT ROCK.

Cement rock from —	Calcium carbonate, $CaCO_3$	Magnesium carbonate, $MgCO_3$	Silica, SiO_2	Silica and insoluble	Ferric oxide, Fe_2O_3	Ferric oxide and alumina	Alumina, Al_2O_3	Potash and soda, K_2O, and Na_2O	Water, H_2O	Water and undetermined	Undetermined	Total	Analyst or authority.
Fort Scott cement rock No. 1, *a*	73.96	2.26	18.75	....	2.32	....	2.15	....	0.37	....	0.20	100.00	Dr. E. Bartow.
" " No. 1, *b*	63.05	12.21	16.64	....	4.43	....	3.09	....	0.26	....	0.32	100.00	"
" " No. 1, *c*	55.40	20.92	18.34	....	6.57	....	1.51	....	0.29	....	1.97	100.00	"
" " No. 2, *a*	60.21	17.30	15.48	....	2.98	....	2.71	....	0.31	....	1.01	100.00	"
" " No. 2, *b*	53.16	26.62	11.75	....	4.59	....	2.06	....	0.33	....	1.49	100.00	"
" " No. 2, *c*	51.12	15.88	24.25	....	5.04	....	2.28	....	0.63	....	0.80	100.00	"
" " No. 3, *a*	65.62	4.43	18.45	....	2.17	....	8.47	....	0.44	....	0.42	100.00	"
" " No. 3, *b*	64.93	11.01	16.27	....	3.87	....	2.91	....	....	....	1.01	100.00	"
" " No. 3, *c*	54.80	4.77	32.07	....	3.40	....	3.99	....	....	....	0.97	100.00	"
" " No. 4	77.90	3.27	13.84	....	1.68	....	2.47	....	....	....	0.84	100.00	"
" " No. 5	81.34	3.82	11.08	....	1.69	....	1.77	....	....	....	0.80	100.00	"
Fort Scott, Kan.	65.21	10.65	....	15.21	....	....	4.56	....	....	....	4.37	100.00	Mineral Industry, vol. I.
Rosendale, Ulster county, N. Y.	45.91	26.14	....	15.37	....	11.38	....	....	....	1.20	....	100.00	" " "
Utica, Ill.	42.25	31.98	....	21.12	....	1.12	....	....	1.07	....	2.46	100.00	" " "
Milwaukee, Wis.	45.54	32.46	....	17.56	3.03	....	1.41	....	....	....	....	100.00	" " "
Cement, Ga.	43.50	22.00	....	22.10	1.80	....	5.45	0.22	4.95	....	....	100.02	" " "
Siegfried, Pa.	78.92	2.66	....	11.62	....	6.25	....	....	....	....	0.55	100.00	" " "

Fort Scott cement rock No. 1 is from the quarries in southeast part of the city. No. 2 is from rock obtained northeast of Fort Scott. No. 3 is from rock at the cement works north of the city, the stratum there being about four feet thick. No. 4 is rock that is considered the best. No. 5 is a rock said to contain too much lime. *a* From top of stratum. *b* From middle of stratum. *c* From bottom of stratum.

The manufactured cement, as shown by different analyses, has the following composition:

TABLE XXIII.—ANALYSES OF NATURAL HYDRAULIC CEMENT.

Hydraulic cement from—	Silica, SiO_2.	Alumina and iron oxide, $Al_2O_3+Fe_2O_3$.	Lime, CaO.	Magnesia, MgO.	Alkalis, Na_2O+K_2O.	Carbon dioxide, CO_2.	Sulphate of lime, $CaSO_4$.	Water, H_2O.	Undetermined.	Total.	Analyst or authority.
Rosendale, Ulster county, N. Y.	22.75	16.70	37.60	16.65	....	5.00	....	1.30	....	100	Mineral Industry, vol. I.
Utica, Ill.	35.43	9.92	33.67	20.98	....	....	....	....	....	100	
Akron, N. Y.	29.64	6.42	54.77	9.17	....	....	....	....	....	100	
Lehigh Valley, Pa.	18.28	7.43	51.58	2.07	1.50	16.26	....	....	2.93	100	
Louisville, Ky.	21.10	7.51	44.40	7.00	0.80	11.18	6.85	1.16	....	100	

demand for hydraulic cement in the West at that time was exceedingly limited. When the M. K. & T. railroad reached Fort Scott they commenced the use of Fort Scott hydraulic cement, and used it in all their bridges between Fort Scott and Texas, with the best results, and have used large quantities annually since.

"The first full car-load of Fort Scott cement was shipped in 1870, and was used in the Arkansas river bridge. The Kansas City, Fort Scott & Gulf railroad about that time also adopted the use of the Fort Scott hydraulic cement. The New York Construction Company, of New York, used 300 barrels in building the gas-works at Jefferson City, Mo., paying for the same three dollars per barrel free on board cars at Fort Scott. In 1871 the capacity of the works was increased to fifty barrels per day, and the price reduced to three dollars per barrel. In 1872 the Fort Scott cement was used at Humboldt, Emporia, Wamego, Junction City, and Topeka, a car-load being shipped to each place at three dollars per barrel, and was also introduced at Kansas City, Mo., and other points, and in 1873 it was used in the construction of the water-works at Kansas City, Mo. The reservoirs built in that year and lined with Fort Scott cement are in most excellent condition after twenty-four years of use.

"In 1874 Mr. C. H. Boyle bought the works and increased the capacity to 100 barrels per day. In 1879 Mr. C. F. Drake purchased back the works, still further increased their capacity to 500 barrels per day, and leased the plant to B. F. Gardiner, who operated the works until his death, after which they were purchased by the C. A. Brockett Cement Company and have since been operated by it under the corporate name of the Kansas City and Fort Scott Cement Company. The capacity of the works has been increased to 700 barrels per day.

"In 1887 another plant for the manufacture of Fort Scott hydraulic cement was built on the line of the Kansas City, Fort Scott & Memphis railroad, about two miles north of the city of Fort Scott. This mill is owned and operated by the Fort Scott Hydraulic Cement Company, and its capacity is about 700 barrels per day, making the total daily capacity of the two cement mills about 1400 barrels. Owing to improved machinery, the cost of producing hydraulic cement during the last several years has been greatly reduced, and the cement is now sold at a price not exceeding seventy-five cents per barrel, free on board cars at the mills. It will be seen, therefore, that the industry started on so small a scale has become one of considerable importance, and has been of great advantage to the city of Fort Scott, as well as to the state. The two companies employ a large number of men in their quarries, and in their mills in the manufacture of the cement, for which they find a ready sale.

"Fort Scott hydraulic cement has been used by nearly all the railroads throughout not only Kansas, but the adjoining states, and the two companies market their product in Kansas, Missouri, Texas, Arkansas, Louisiana, Indian territory, Iowa, Nebraska, Colorado, and New Mexico. Some 30,000 barrels or more are used annually in the public works of Kansas City, Mo., and the annual output of the two companies is now about 160,000 barrels. It should be borne in mind that, with the improved machinery of the present day, hydraulic cement can be made so cheaply that it is sold in the market at a price not greatly exceeding that of ordinary lime, and in all the large cities it is being used to the exclusion of lime mortar in brick and stone work and its use should become general.

"The process of manufacture is as follows: The cement rock, when quarried and broken into pieces of suitable size, is properly burned in kilns constructed especially for the purpose. After the important process of calcination the material is drawn out of the kilns and carefully inspected. As much of it as is properly burned is sent to the mills, to be finely ground and otherwise prepared for the market. Great care and a thorough knowledge of the art of making cement are indispensable to the production of an article of such quality and character as will give general satisfaction and insure uniform results. After the cement is properly prepared it is packed into barrels, paper sacks, and cotton bags and shipped to points of destination."

TABLE XXIV.

SHOWING AMOUNT AND VALUE OF HYDRAULIC CEMENT PRODUCED IN KANSAS.

The figures from 1888 to 1896, inclusive, are based upon the reports given by the U. S. Geological Survey.

Year.	Barrels.	Price per barrel.	Value of output.
1888	40,000	75 cts.	$30,000
1889	150,000	70 "	105,000
1890	150,000	70 "	105,000
1891	140,000	69 "	97,440
1892*	110,000	69 "	77,000
1893	60,000	35 "	21,000
1894	50,000	50 "	25,000
1895	140,000	40 "	56,000
1896	125,567	40 "	50,226
1897	160,000	40 "	64,000
Totals	1,125,567	....	$600,666

*Includes Kansas City, Mo.

VIII.—BUILDING STONE.

KANSAS has two kinds of building stone: sandstone and limestone. There are but few good quarries of the former within the state, excepting the quarries of flagging stone, which in some places supply a great abundance of stone of superior quality. The limestone is particularly abundant in the Coal Measure and Permian areas of the eastern third of the state, although some quarries are worked to a considerable extent farther west, in the Benton and Niobrara.

Sandstone.

The sandstone of Kansas, so far as quarries have been opened, is confined entirely to the Coal Measures of the state, and principally to the southeastern corner of the state. In Cherokee county, numerous quarries of flagging stone are, or have been, operated, and an occasional quarry producing dimension stone. Crawford and Bourbon counties likewise have quarries of flagging stone, with occasional quarries supplying dimension stone.

Further west, in the vicinity of Thayer, Neodesha, and Independence, a considerable quantity of dimension stone has been quarried in earlier times from the heavy beds of sandstone which are found in many places; but almost all of these quarries are abandoned at the present time. Other portions of the state have furnished almost no sandstone at any time in our history, and at present are practically furnishing none.

Dimension Stone.—In Cherokee county, to the east and southeast of Columbus, at many points for a distance of from six to eight miles, dimension sandstone has been obtained of a fair quality, and has been used in bridge building and in laying foundations for houses in Columbus and other towns and for supplying a considerable demand from the rural districts. Such stone was quarried as early as 1866 by the settlers who located in Cherokee county. In those early days it was usually customary for the individual farmer to quarry the stone he wanted, either from his own land or from that of a neighbor. There was no special market for it, and therefore the quarries were not operated regularly. In later times, as Columbus began demanding permanent improvements, large quantities of the stone were produced at a considerable number of quarries, and were used for the

foundations of buildings and for rough walls. A few buildings in Columbus have been erected entirely from sandstone sawed into blocks of proper size thereby providing a smooth and handsome wall.

Numerous buildings in Thayer, Chanute, Neodesha and Independence likewise have heavy sandstone for the basement, and in many cases the entire building is made of stone. The stone at Thayer principally comes from quarries lying south and west of the town. Those in Neodesha are obtained from the heavy sandstone immediately under the town, the quarries principally being along the bank of the creek just at the northeast border. The sandstone quarries in the vicinity of Independence are located in diffent directions from the town, some of them near by and some of them on the hills to the east and northeast. As there has been but little done in the way of the erection of new buildings and in railroad construction and bridge building during recent years, there has been but little demand for dimension stone, and therefore the sandstone quarries have been worked almost none throughout all this country for a number of years.

Flagging Stone.—Kansas produces a much larger quantity of flagging sandstone than of dimension sandstone. Quarries producing broad, smooth stone of great size have been and are now being operated in many different places here and there throughout the southeastern eighth of the state. The Coal Measures sandstone frequently is found with conditions particularly favorable for the production of excellent flagging stone.

In Cherokee county the extreme southeastern part of the hilly land lying to the southeast of Columbus is a notable place for such quarries. Here on the hills in the vicinity of the so-called "timbered hills," near Tehama post-office, the stone is found in unusually broad, smooth layers, suitable for all kinds of flagstones. Formerly the farmers living near these quarries supplied themselves with stone for building stone walls of various kinds, and not infrequently stables and small barns were roofed with them, the broad, thin stones being lapped over each other, somewhat similar to shingles on a roof. Such stone was also used locally for the manufacture of grindstones and abrasive stones of different kinds, being particularly suitable for this purpose. The rock at this place is of a light buff color, the sand grains are sharp and well held together by the cementing material, and the rock is particularly free from earthy impurities. Should a location be desired by a company for the extensive manufacture of grindstones and other grit-stones where coarse grains are desired, this would be a most excellent locality. It is the common testimony of the few people who have used these home-made grindstones, that they are far superior, in abrasive capacity, to any of the more neatly

dressed goods obtained on the general market. At present these quarries are practically abandoned, principally on account of the long distance they are from railroad stations.

Farther to the east and on lower ground, about four miles south of Crestline, J. R. Burrows & Sons have been operating a quarry of flagging stone for ten or more years. They have an excellent grade of sandstone which occurs in broad, smooth, thin layers, sufficiently free from fissures to produce flags of any desired size. The principal market Messrs. Burrows have found for their stone is at Galena. For a number of years they have constantly been carting the stone to Galena, where they have been laid in walks and in curbing. A visitor to Galena will notice that more than half of the sidewalks in that thrifty town are made of sandstone, nearly all of which came from the Burrows quarry. For the last year the demand for sidewalk building has been much less than usual, Mr. Burrows stating in his report that their total output for 1897 was only about one-half what it had previously averaged.

At different places along Brush creek, to the southeast of Columbus, flagging stone has been quarried and hauled to Columbus and elsewhere for sidewalks and other purposes, although no other quarry has been operated so extensively as the two already described.

Crawford county likewise is capable of producing untold quantities of flagging stone. Just to the northwest of Farlington, only a short distance from the station, two or more quarries have been opened in beds of flagging stone of unsurpassed quality. Blocks can be obtained here of any desirable size, with a thickness varying from three to six inches, and with a surface almost as true and even as a floor. Stone from these quarries have been taken to Girard and used there liberally in sidewalk building. This is the only place in the county known to the writer where quarries are opened and in operation producing flagging stone, but it is well known that other localities could be found where similar quarries could be operated.

Bourbon county perhaps has turned out more flagstone than any other county in the state. The same sandstone horizon operated at Farlington extends northward and supplies untold quantities of flagging-stone material. The quarries are operated in the vicinity of Gilfillan, Redfield, and Bandera, from which stone is shipped to all points in eastern Kansas and western Missouri for sidewalk purposes. Hardly a city of any considerable importance can be visited but that the Fort Scott flags will be found in the walks. Here the rock occurs in broad, thin layers, with smooth surfaces similar to those already described. It is probable that this county alone could supply a thousand times the amount of flagstone annually used by the entire state.

Labette and Neosho counties have some good flagstone quarries. This is particularly true at different places in the northeast part of Labette county and the southeast part of Neosho county, where the same geological horizon outcrops which carries the Farlington, Redfield, Gilfillan, and Bandera flags. Mr. Robinette, living near the southeast part of Neosho county, for a number of years has operated the quarries on the west bank of the Neosho river from which flagstones were hauled to Parsons and other towns for the construction of walks.

Farther west, in the Dakota sandstone areas, a considerable amount of sandstone has been quarried for local use. Almost every town and village in such areas have basements of their buildings made principally from the Dakota sandstone, and many of the buildings themselves are of the same. At present, however, but little quarrying is done in the Dakota sandstone area, although a strip of country reaching from the north side of the state in Washington county to the Arkansas river in Edwards county is covered by the Dakota sandstone, so that in almost every township valuable stone could be obtained if desired.

Along the southern part of the state the poorly cemented sandstone of the Red Beds has furnished building material to a limited extent. One large building in Harper is constructed entirely of the Red Beds sandstone, and many other buildings have the basement made of the same material. This rock, however, is not of sufficient value for extensive use.

Limestone.

Limestones are quarried in Kansas much more extensively than sandstones. Of the statistics for 1897, more than 88 per cent. represent limestone.

In the southeastern part of the state a small amount of quarrying is done in the Subcarboniferous limestone at and near Galena. This limestone is a highly crystalline one, very compact in character, light blue in color, and occurs in heavy layers, so that large dimension stone could be obtained from it, were the quarries operated for that purpose. It is the same rock in every respect, both as to geologic age and general character, that is so extensively quarried at Carthage and other points in Missouri. From the Carthage quarries many thousands of dollars' worth of stone are shipped into Kansas, all of which might be supplied from the Kansas stone if quarries were worked as extensively as might be done. The quarries at Galena are operated to supply local demand, and that only for foundation material in buildings, although considerable dimension stone is shipped from Carthage into Galena for the larger buildings.

Years ago this same stone was quarried at Galena, at Lowell, and elsewhere for the production of lime. It is so abundant in quantity and so easily accessible along the hillsides that it is a great wonder more lime kilns are not in operation. The same rock is quarried at different places in Missouri and burnt into lime, producing lime of a good quality, but no better than might be obtained from Kansas quarries.

To the northwest of Cherokee county many local quarries in heavy limestone formations have been operated, some of which are still operated in an irregular manner. The most extensive of these is the quarry at Iola, which has produced large quantities of dimension stone and sawed flagstone for local trade and for shipment to other points. The limestone at Iola exists in a layer nearly forty feet thick, from which dimension blocks of any size or proportion desirable can be obtained.

Still further to the northwest the next quarries are those along the banks of the Kansas river west of Kansas City, from which large quantities of stone are taken for ballast and for macadamizing streets. Near Kansas City a deposit of fragmentary material exists from which large quantities have been shipped for making sidewalks and for macadamizing streets and for similar purposes.

Other places furnish quantities of stone, the output of which would be greatly increased if the demand were sufficient to justify the extensive operation of quarries. Generally, however, it is principally a local demand, for which no statistics can be gathered, but which in the aggregate amounts to many thousands of dollars.

Still farther west a limestone exists which is remarkable in many of its properties, permitting it to be successfully quarried for all kinds of dimension stone wherever it comes to the surface. It is known commercially as the Cottonwood Falls limestone, because such large quantities have been shipped from Cottonwood Falls and Strong City to so many points within and without the state. The same rock has been quarried at a dozen or more places to the north of Cottonwood Falls, such as Eskridge, Alma, Manhattan, Beattie, and a number of other places. This limestone is not very thick, averaging from five to eight feet, and generally consists of two individual layers, known in the markets as the "upper" and the "lower." The rock from the two layers differ slightly in quality, the lower one generally producing the best stone. Its most valuable properties are two: almost perfect uniformity of texture throughout, and the absence of vertical fissures. It is white or light cream in color, fine and non-crystalline in texture, and well filled with the little rice-grain-like invertebrate fossil, ***Fusulina cylindrica***. The color is so uniform that when the stone is placed in

a building the general color effect is very pleasing and satisfactory. The absence of vertical fissures and the uniformity of texture throughout make it possible to obtain dimension blocks of any size desired, which can be worked with perfect uniformity. These qualities make it by all odds the most desirable and therefore the most extensively used stone in the state. Large buildings are erected from it entirely, and many others partly constructed from the same rock. The different quarries so widely separated make it possible for a large community to use it without paying excessive freight.

From this Cottonwood Falls limestone the following important buildings are constructed: Snow hall, and the stone trimmings of the main building, University of Kansas, Lawrence; the M. E. church, Lawrence; the Rock Island depot, Topeka; the Santa Fe depots at Ottawa, Wellington, and elsewhere; and a number of other depot buildings along the lines of the different railways in Kansas.

In addition to the above-mentioned uses, the different railroads in the state use the Cottonwood Falls limestone for bridge building and other construction purposes. This is true to so great an extent that many thousands of dollars' worth of dimension stone are annually supplied the different Kansas lines for use in this state and elsewhere, much of it being shipped outside of the state.

A few hundred feet above the Cottonwood Falls limestone are heavy beds of the Permian limestone, which are unusually filled with flint nodules. These soft Permian limestones, carrying so much flint, are very serviceable for railroad ballast, and are extensively quarried and crushed for this purpose at different places. The quarry near Strong City has probably yielded more ballast of this kind than any other one in the state, but extensive quarries are operated farther west along the Santa Fe at Florence and near Marion, and along the Rock Island at different points, all of which produce practically the same kind of stone.

In the central and west-central part of the state, the Cretaceous limestones have been quarried to a great extent. On account of their soft, chalky character, they are generally spoken of locally as a magnesian limestone, although such a term is entirely misapplied. A belt of country stretches across the state, by way of Beloit and Russell, throughout which a fine layer of limestone is quarried and broken into pieces suitable for fence posts. Travelers passing from east to west along almost any railroad line in the state can notice large fields and pastures fenced entirely by fastening the wire fencing to these stone posts, which are set in the ground similar to the way common wooden posts are used in ordinary fencing. The Cretaceous limestones also serve many structural purposes in all of the cities and vil-

lages within the Cretaceous area. The rock is so soft it can easily be sawed into blocks, and worked with chisel and hammer much more rapidly than ordinary limestone. This, added to its property of materially hardening after quarried, greatly increases its value. None of it is what would be called a first-class building material, yet it is capable of being used in many ways to a great extent, and furnishes a convenient and durable structural material for that part of the state, which tolerably effectually prevents other stone from being shipped in. Here, as elsewhere, local demands are not so great now as they formerly were, but every year thousands of dollars' worth of the rock are quarried and used for various purposes, principally for supplying fence posts.

A large amount of work, in systematically examining the Kansas building stone, has been performed by members of the University faculty. This was particularly true during the years 1892 and 1893, at which time a large collection was made, from almost all over the state, by Professor Williston, and many chemical analyses made by Professor Bailey and his assistants, in the chemical department, and crushing tests made by Professor Marvin and his assistants, in the engineering department. This work was done especially for the exhibit of Kansas building stone at the World's Fair. The results of the investigation have not yet been published. A synopsis of it, however, was published in the Sixteenth Annual Report of the Director of the United States Geological Survey, part III, page 504, from which the following tables of chemical and physical properties are taken:

TABLE XXV.—TESTS AND ANALYSES OF KANSAS BUILDING STONES. LIMESTONE.

Counties.	Formations.	Crushing strength.	Weight per cubic foot.	Specific gravity.	Ratio of absorption.	Analyses.						Remarks.
						Insoluble matter.	Oxides of iron and alumina.	Calcium carbonate.	Magnesium carbonate.	Sulphates.	Moisture.	
		Lbs.	Lbs.			%	%	%	%	%	%	
Johnson	....	19,279	165.4	2.65	.01	8.00	1.35	90.00	.12	.02	....	From Ottawa; average from three blocks.
Allen	....	....	....	....	....	1.53	1.75	94.12	2.72	....	....	From Humboldt.
Leavenworth,	....	7,862	168.5	2.70	.02	5.91	2.47	89.88	1.11	.38	....	From Lansing; average from five blocks.
Leavenworth,	....	15,961	169.1	2.71	.004	6.20	3.31	88.17	1.88	.28	.04	From Lansing.
Cowley	Permian	....	165.4	2.65	.045	13.60	2.55	76.16	7.63	....	....	From Arkansas City; fine grained and homogeneous; no appearance of fossils.
Cowley	Permian	4,555	157.3	2.52	.07	4.25	.85	94.06	.62	....	....	From Winfield.
Marion	"	....	167.0	2.67	.07	5.13	3.15	53.16	38.33	....	....	From Marion; this stone appears to have nearly the composition of dolomite; it is fine grained, takes a smooth surface, and is gray in color.
Marion	Carboniferous	5,824	169.8	2.72	.01	6.85	1.91	59.21	30.09	.95	.90	From Marion.
"	Permian	8,136	167.6	2.68	.05	13.51	1.65	61.64	22.72	....	....	From Marion; produced by I. Kuhn & Co.; dark gray; not perfectly homogeneous, occasional spots.
Marion	Permian	13,711	170.7	2.73	.04	6.75	1.59	51.05	40.51	....	....	Produced by I. Kuhn & Co.; average from four blocks; five miles northeast of Marion.
Marion	Permian	12,364	168.2	2.69	.03	5.51	1.24	91.50	1.62	....	....	
Clay	"	10,291	170.4	2.73	.05	9.50	6.40	60.04	24.72	....	....	From Clay Center; average from three blocks.
Butler	Permian	2,727	162.9	2.61	.01	5.04	.96	93.32	1.06	....	....	From El Dorado.
Douglas	Carboniferous	11,630	167.6	2.68	.007	3.53	1.07	94.18	1.16	....	....	Crushing strength is the average from five blocks; from Lawrence.
Franklin	....	2,940	162.0	2.59	.03	1.18	3.09	92.71	2.64	....	....	From Greeley.
Leavenworth,	....	8,223	170.4	2.73	.01	12.97	3.06	78.46	1.16	2.32	....	From Lansing.
Marshall	....	4,216	158.8	2.54	.06	13.89	4.29	80.10	1.00	.39	....	From Beattie; average from five blocks.

TABLE XXV—Concluded. TESTS AND ANALYSES OF KANSAS BUILDING STONES. LIMESTONE.

Counties.	Formations.	Crushing strength	Weight per cubic foot	Specific gravity	Ratio of absorption	Analyses. Insoluble matter	Analyses. Oxides of iron and alumina	Analyses. Calcium carbonate	Analyses. Magnesium carbonate	Analyses. Sulphates	Analyses. Moisture	Remarks.
		Lbs.	Lbs.			%	%	%	%	%	%	
Marshall		9,810	163.2	2.61	.03	8.75	2.37	84.80	2.80	.78	.25	From Beattie; average from five blocks.
"	Carboniferous	6,543	163.5	2.62	.05	14.01	1.34	80.31	3.87	....	....	From Beattie; average from four blocks.
Riley	Permian	3,272	159.1	2.55	.07	.....	.....	.....	.....	....	....	From Manhattan; quarried by Ulrich Bros.
Wabaunsee		......	166.3	2.67	.01	6.22	1.74	89.68	1.99	....	...	From Alma.
"	Carboniferous	7,646	161.3	2.58	.05	9.12	.70	88.55	1.25	....	....	From Alma; quarried by A. Zechser.
"		2,891	154.4	2.49	.66	10.37	2.49	84.53	2.35	....	....	Crushing strength is the average from five blocks.
Chase	Carboniferous	7,907	162.9	2.61	.04	7.30	1.05	90.00	1.60	.03	....	From Strong City; average from six blocks.
"		6,800	161.6	2.59	.04	8.57	3.62	84.72	1.75	.90	....	From Cottonwood Falls; quarried by Rettiger Bros.; crushing strength, average from four blocks.
Cowley		12,567	164.5	2.63	.01	3.34	1.69	93.98	.94	....	....	From Cambridge; quarried by H. Heddeman; average from five blocks.
Cowley	Carboniferous	3,649	153.5	2.46	.08	.....	.....	.....	.....	....	....	From Cambridge; average from five blocks.
Lincoln	Benton Cretaceous	......	.....	.....	.....	.....		.....	.....	....	....	No data; known as Lincoln marble, but is hardly a marble, not being sufficiently crystalline.
Hodgeman		......	.....	.....	.....	5.06	2.08	91.30	.87	b...	.44	From Jetmore.
Hamilton	Benton Cretaceous	......	.....	.....	.....	4.81	3.07	90.63	.84	b...	.08	From Coolidge.
Norton	Loup Fork Tertiary	4,277	156.3	2.51	.06	8.29	a .90	89.00	2.00	....	....	From Norton; crushing strength, average from four blocks.
Cherokee	Subcarboniferous	9,520	166.0	2.66	.003	8.00	.69	97.32	.80	....	....	From Galena.
Allen		......	167.3	2.68	.02	2.75	5.91	91.02	.14	....	....	Iola Marble Company.
"		7,683	166.0	2.66	.02	2.63	1.76	94.10	1.54	....	....	Av. crushing strength—five blocks.

Montgomery..	....	7,731	169.8	2.72	.006	16.15	1.91	79.25	1.80	....	....	From Independence.
Barber [b]......	....	10,349	163.5	2.62	.01	1.85	1.95	94.62	1.40	....	....	Average from six blocks.
Franklin.....	....	12,809	167.3	2.68	.008	1.18	2.38	94.77	1.07	....	....	From Lane; quarried by Hanway.
"	....	14,415 / 16,609	169.8	2.72	.005	3.82	[a].77	94.21	1.30	....	....	" " " "
"	....	10,469	167.9	2.69	.009	3.94	1.20	93.61	1.20	....	....	" " " "
"	....	12,354	167.9	2.69	.006	4.79	1.18	93.30	1.26	....	....	" " " "
Anderson	Carboniferous	14,647	168.2	2.69	.004	4.30	.81	92.76	.95	.23	.43	From Garnett.
"	....	4,399	154.2	2.47	.04	.61	[a]1.51	97.32	.32	.43	....	" "
Jackson......	....	11,005	163.5	2.62	.02	10.93	2.02	83.99	2.66	.14	....	Quarried by A. W. Charles.
Woodson.....	....	14,145	168.2	2.69	.007	6.80	2.60	88.03	2.04	.21	....	From Yates Center.
Elk..........	....	10,162	166.2	2.66	.008	.66	2.13	93.49	3.04	.36	....	From Moline.
Leavenworth,	....	5,515	160.4	2.57	.02	17.49	4.09	69.07	3.06	.37	....	From Soldiers' Home.
Wabaunsee ..	....	5,273	156.3	2.50	.06	3.27	2.61	92.50	1.62	....	....	From McFarland; average from five blocks.
Miami.......	....	2,036	128.2	2.50	.06	1.50	.95	96.50	.74	....	....	From Fontana.
"	....	13,802	165.4	2.65	.004	1.35	1.32	96.09	1.00	....	....	From Fontana; crushing strength, average from four blocks.
Miami	....	4,625	145.4	2.33	.04	2.44	.82	95.57	.80	....	....	From Fontana; crushing strength, average from five blocks.
Jefferson.....	....	8,767	169.8	2.72	.005	6.98	1.04	90.01	1.66	....	....	From Winchester.
Nemaha	....	6,757	161.6	2.59	.05	11.97	3.59	81.98	1.20	.55	[b].29	From Sabetha.
Leavenworth,	....	12,266	161.1	2.71	.01	......	......	......	......	....	....	From Lansing; crushing strength, average from five blocks.
Brown	....	4,721	164.5	2.63	.06	11.83	5.53	81.91	1.56	.05	....	From Horton; owners, Frey Bros.; crushing strength, average from five blocks.
Douglas	....	10,339	166.6	2.67	.01	2.29	1.79	95.02	.79	....	....	From Lawrence; crushing strength, average from five blocks.
Douglas	....	11,038	166.6	2.67	.01	8.02	2.05	88.54	1.29	....	....	From Lawrence.
Allen	....	17,160	168.8	2.70	.008	1.99	1.21	95.20	1.10	....	....	From Humboldt; crushing strength, average from three blocks.
Allen	....	11,267	166.0	2.66	.02	3.79	1.07	93.20	1.01	.20	....	From Humboldt; crushing strength, average from five blocks.

a In ferrous state. *b* Not determined.

All of these limestones are fossiliferous in appearance. The surface appears to polish very well. Fossil outlines are very distinct in most of them. The prevailing color of the samples is a sort of gray, occasionally brownish. The polished surface of certain bluish-gray specimens is quite dark. The polish of some of these stones is very good indeed.

The above table is from the Sixteenth Annual Report of the U. S. Geological Survey.

The actual commercial importance of the Kansas stone quarries for 1897 is shown in the appended statistical tables, in which is given the total output of the Kansas quarries for 1897 and preceding years. It is impossible to estimate the total value of stone quarried in Kansas; so many thousands of cords have been taken out a little at a time by the individual farmers and by the local dealers to be used in the foundations of buildings and the construction of bridges and in many other ways, that nothing but the merest guess could be applied to them. It is well within the limits of probability, however, to say that more than five million dollars' worth of stone have thus been produced.

The future prospect of our quarries is dependent almost entirely upon the extent of internal improvements in Kansas and adjacent territory, and the largest proportion of stone will come from the Cottonwood Falls series of limestone for reasons already given. Should a demand be created, the quarries already in operation and others which would soon be put in operation would readily supply many times the amount they thus far have produced.

TABLE XXVI.

SHOWING VALUE OF BUILDING STONE PRODUCED IN KANSAS FROM 1888 TO 1897.

Figures for 1880 to 1896, inclusive, are taken from the reports of the United States Geological Survey.

Year.	Sandstone.	Limestone.
1880	$11,000	$131,570
1888*	1,000	144,000
1889	149,289	478,822
1890	149,289	478,822
1891	80,000	300,000
1892	70,000	310,000
1893	24,761	175,173
1894	30,265	241,039
1895	93,394	316,688
1896	18,804	158,112
1897	23,180	173,000
Totals	$650,972	$2,907,226

*Reports for 1888 include only (for sandstone) the production from Ritchie; and (for limestone) the production from Winfield, Florence, Augusta, and Oketo.

The Nesch Brick-Yards, Pittsburg.

The Nesch Brick-Yards, Pittsburg.

IX.—CLAYS.

KANSAS has a great abundance of clays suitable for the manufacture of all grades of the more common clay goods. In the northeastern part of the state the glacial loess clays abound, and furnish the different varieties common to other glacial areas, such as Iowa, Missouri, Illinois, Indiana, Ohio, etc. Throughout all the eastern part of the state the Coal Measure shales occur, and supply clay for brick making and ordinary pottery ware. Further west, in the Permian of the state, particularly in the Flint hills area, the clay shales have smaller per cents. of impurities than the Coal Measure shales do, and probably could be used to advantage for many of the higher grades of ware should any one ever put them to such a use. Beyond the Permian, in the Dakota, Benton, and Tertiary areas, many places are known where good clays exist in large quantities suitable for all kinds of brick work and for the manufacture of earthenware.

Thus far no deposit of first-class fire-clay or clay sufficiently pure to make the highest grade of queensware or porcelain has been discovered. Could a deposit of good fire-clay be found in the eastern part of the state — a fire-clay suitable for retorts — it would be of great value. During 1897 our Kansas zinc smelters consumed 5757 tons of fire-clay in their smelting operations, all of which was shipped into the state from outside localities. In addition to the consumption of fire-clay by our zinc smelters, there would be a ready market for it in limited quantities for many other enterprises in different parts of the state, and it could even be shipped outside the state at remunerative figures.

Uses of Kansas Clays.—At present the Kansas clays are used principally for the manufacture of drain tiling, paving brick, pressed brick, and common brick. In addition to these, in the history of our state a number of factories have been established for the production of the cheaper grades of stoneware, and in the aggregate large quantities of clay have been consumed for this purpose.

The clay industries are principally confined to the eastern side of the state. On account of the cheapness and desirability of gas as a fuel, the natural-gas area is destined to become the center of our clay industries, and already can almost claim that title. Next in impor-

tance is the great coal area, where fuel is but little more expensive than in the gas fields.

Beyond the areas of cheap fuel the principal factor controlling the location of plants for the manufacture of clay goods is that of market. Wherever there is a great demand for brick there brick factories will be located, unless the absence of clay and the high price of fuel positively prevents. During the periods of municipal improvements and building, brick factories sprang up and flourished for a time to supply local demands and later declined or entirely disappeared. There is scarcely a town in all eastern Kansas which has not at one time had a factory for the manufacture of different kinds of brick. Some of these factories are still in existence, while many of them, having served the purpose for which they were constructed, are discontinued. Should there be a return of extensive municipal improvements within our state, or should street paving with brick become general in our Kansas towns, there would be a great expanse of brick making, equaling or surpassing anything our state has ever witnessed.

The following tables show the present status of the clay industries in Kansas:

TABLE XXVII.

SHOWING AMOUNT, KIND, AND VALUE OF KANSAS CLAY PRODUCTS IN 1897.

Number of firms reporting, 32.

Description.	Quantity, in thousands.	Average price per M.	Value.
Common brick	19,548	$5 33	$104,256 71
Pressed brick	1,948	5 26	10,241 49
Vitrified brick	18,378	7 18	132,222 07
Fire brick	100	10 00	1,000 00
Drain tile	....	....	7,600 00
Other clay products	....	....	10,000 00
Totals	39,974	....	$265,320 27

TABLE XXVIII.

SHOWING AMOUNT, KIND, AND VALUE OF KANSAS CLAY PRODUCTS FROM 1892 TO 1897.

Figures for 1893 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

Year.	Common brick.			Pressed brick.			Vitrified brick.			Drain tile, value.	Other clay products, value.	Total value.
	Number of thousand.	Av. price per M.	Value.	Number of thous'nd.	Av. price per M.	Value.	Number of thousand.	Av. price per M.	Value.			
1892[1]	25,000	$5 75	$142,750	550	$7 50	$4,125	10,600	$8 00	$84,800	$6,000	$5,000	$242,675
1893[2]	20,000	5 75	115,000	1,000	7 50	7,500	8,000	8 00	64,000	5,000	4,500	196,000
1894[3]	24,518	5 75	141,042	......	......	....	7,948	7 21	57,310	8,048	12,175	218,575
1895	20,756	5 87	121,892	3,730	6 91	25,775	7,902	7 87	62,190	4,090	33,700	247,647
1896	19,694	5 59	110,254	1,541	6 13	9,440	16,934	7 39	125,293	4,400	10,700	260,087
1897	19,548	5 33	104,257	1,948	5 26	10,241	18,378	7 18	132,222	7,600	11,000	265,320
Totals	129,516	......	$735,195	8,769	......	$57,081	69,762	......	$525,815	$35,138	$77,075	$1,430,304

1. Only a partial report is obtainable for 1892.
2. Estimated.
3. For 1894 the common and pressed brick were figured together.

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Mineral Resources of Kansas.

1898.

Gold and Silver.
Lead and Zinc.
Coal.
Oil and Gas.
Gypsum.
Building Stone.
Clay Goods.
Hydraulic Cement.
Salt.

THE

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FOR ANNUAL BULLETIN ON MINERAL RESOURCES OF KANSAS FOR 1898,

ERASMUS HAWORTH, Geologist.

Dr. F. H. Snow, Chancellor of the University of Kansas:

SIR—I have the honor to submit to you herewith my annual report on the mineral resources of Kansas for the year 1898, which will constitute the second annual bulletin of this series.

Yours most respectfully,

ERASMUS HAWORTH.

DEPARTMENT OF PHYSICAL GEOLOGY AND MINERALOGY,
UNIVERSITY OF KANSAS, June 30, 1899.

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INTRODUCTION.

THIS report of the mineral industries of Kansas for 1898 has been delayed in preparation, due to unavoidable causes.

The year 1898 was an unusually prosperous year for almost all mining enterprises within the state. The output of zinc ore was the greatest in value ever known in the state; the output of lead ore fell far short of that of preceding years. But the combined value of the two was greater than that of any other year in the history of lead and zinc mining in Kansas. The zinc smelting business was unusually successful, due principally to the extended application of natural gas as a fuel in smelting; but the amount of spelter produced for 1898, great as it was, is much smaller than that which will probably be produced during 1899, as a number of smelting establishments began operations early in 1899.

During the year the two lead smelting furnaces at Galena were in successful operation more than half the time, so that we again have our Kansas lead ore principally smelted on Kansas territory. This is the first time that such has been accomplished for a long period of years, and is therefore exceedingly gratifying to all our public spirited citizens.

The operations of the Argentine Smelting and Refining Company were very successful throughout the year, particularly in their gold refining department, where the business transacted exceeded five million dollars. There was a considerable decrease in the amount of silver refined. The copper and the zinc produced at the refinery were entirely changed into blue vitriol and white vitriol, instead of being marketed in the metallic form. In 1897 the lead at this factory was likewise very largely changed into litharge, but in 1898 no litharge was manufactured.

There was great activity in the coal industry during 1898. The

total output of Kansas mines aggregated 3,860,405 tons; over half a million tons in excess of the output of 1894, which year had the next heaviest production. The price of coal, however, was but little more than in previous years, averaging for the entire state and for all kinds of coal a value at the mines of $1.08½ per ton, giving a total value considerably over $4,000,000, which is larger than the aggregate value of any preceding year excepting 1894, when coal had an average value of $1.35 per ton. An interesting feature of the coal mining, however, was that there was a general decrease of production in all localities outside of Cherokee and Crawford counties, with a correspondingly great increase in these two counties.

The oil refinery at Neodesha consumed the total output of petroleum for the year. There is such a relation between the refining company and the Forest Oil Company (the principal producing company), that no more oil is produced than the refinery wishes to handle. The production was considerably greater than that of the preceding year, but probably not nearly so great as it could have been made had the refinery demanded more.

The production of natural gas during the year was much greater than that of any preceding year, due principally to the large demand for it as fuel in zinc smelting. The zinc smelters use it without measuring the amount that they consume, and it is therefore difficult to make a reliable estimate of the value of the gas thus produced. In the table which follows in the body of this report the value of the gas consumed by the various cities was taken directly from figures furnished by the several secretaries of the gas companies. That consumed by the smelters was estimated upon the amount of spelter produced at the gas furnaces by allowing three and one-half tons of coal slack to the ton of ore, and using the value for the slack as given in the coal-mining district. There may be serious objections to this mode of estimating the value, but it is the best method known.

The output of salt reached over 1,800,000 barrels, which is considerably larger than that produced during the preceding year, the nearest approach to these figures being in 1892. The value of the salt is unprecedentedly low, averaging for the year twenty-seven cents per barrel, making an aggregate value of nearly half a million dollars. To

this sum the cooperage should be added, to express the correct idea of the magnitude of the salt industry. With a cooperage of twenty-five cents per barrel, the salt industry reached a total of nearly a million dollars. It is a curious fact that the value of the salt in the barrel was but two cents greater than the value of the barrel.

The gypsum and gypsum cement industry was not as active during the year 1898 as in preceding years, neither was the value per ton as great. The Acme Cement Company has withdrawn from the state. Other plants likewise were, in general, less active than in preceding years. The new mills at Mulvane, now in successful operation, were not completed until about the 1st of January, 1899, so that their output does not affect the returns for 1898.

The hydraulic cement industry is still confined entirely to Fort Scott, where the two factories did a business about the same as in 1897, producing 160,000 barrels, with an average value of thirty-eight cents per barrel.

It is difficult, in fact almost impossible, to gather reliable figures on the stone industry of the state. The large stone companies respond very promptly in general to letters of inquiry regarding their output. But there are so many small quarries here and there over the state, the locations of which are not known to the writer, quarries which individually are of little importance, but which collectively amount to a great deal, that the sum total of the stone industry as given is, after all, a mere estimate. The writer would esteem it a great favor if every quarryman in the state who may chance to read these pages would send him his name and address, so that a correct directory of the stone quarries of the state may be compiled.

The year just past has been a prosperous one for the manufacturers of the various kinds of clay goods, particularly for the brick factories. The total product reached an aggregate value of nearly $400,000, which is far above that of any other year. The greatest increase was in vitrified brick, which are now so extensively used in street paving, the second greatest increase being in common building brick. With the increased demand for various kinds of building material already manifested for the year 1899, one may confidently expect that the brick industry in a short time will reach a magnitude very gratifying to all our citizens.

TABLE I.

SHOWING VALUE OF EACH OF THE MINERAL PRODUCTS OF KANSAS FOR 1898, AND SINCE INDUSTRY BEGAN.

Products.	Values for 1898.	Totals by divisions for 1898.	Grand total of production.
NON-METALLIC PRODUCTS.			
Coal	$4,193,159 70		$55,085,641 41
Salt	489,454 23		4,778,655 17
Clay goods	390,630 00		1,820,934 00
Gypsum	129,652 00		1,810,059 00
Stone { Limestone	180,000 00		3,087,226 00
Stone { Sandstone	25,000 00		675,972 00
Natural gas	188,846 00		792,264 00
Oil, refined	176,000 00		358,504 93
Hydraulic cement	60,800 00		661,466 00
Lime (estimated)	65,000 00		1,315,000 00
Sand (estimated)	50,000 00		400,000 00
		$5,948,541 69	
METALLIC PRODUCTS.			
Zinc ore, $1,994,230, yielding metallic zinc	$3,622,768 68		39,286,227 52
Lead ore, $352,798.45, yielding metallic lead	463,464 84		
		4,286,227 52	
SMELTING PRODUCTS.		$10,226,669 21	
Zinc smelting	$3,648,715 57		29,668,342 03
Lead smelting	170,227 01		170,277 01
Argentine smelter	12,920,810 97		127,401,938 67
Total output		$16,739,803 55	
Totals	....	$26,966,472 76	$267,247,358 08

I.—GOLD AND SILVER.

Gold and Silver Ores.

WE have no mines in our state producing either gold or silver. In the Mineral Resources of Kansas for 1897, beginning on page 14, was published a short discussion of the numerous reported finds of gold and silver, all of which have proved on investigation either entirely erroneous or so nearly so that no further attention need be given the subject. During the year 1898 and the early part of 1899 there was a revival of the discussions of gold and silver in different parts of Kansas. The most noted place, the one about which the most has been said, is the locality in the vicinity of Ellis and Trego counties. As early as 1896 considerable excitement was raised by the reported discovery of zinc blende in the northeastern part of Trego county. Many samples were sent to the geological department of the University by different classes of people, property owners, prospective investors, etc. There are a large number of calcite concretions, usually called septaria, in a zone of territory extending somewhat irregularly from Jewell county on the north to Finney on the south. Sometimes these septaria are almost solid calcite. At other times there is a considerable amount of foreign matter in them, although the calcite is the prevailing part. It is stained, probably with decomposing organic matter, giving it a light amber yellow shading into a brown, quite closely resembling in general appearance much of the zinc blende of the Galena mining district. For fully fifteen years people have been mistaking this calcite for zinc ore, lead into the error by the close resemblance in general appearance.

During the summer of 1896 samples of this septarium calcite began reaching us, with requests that it be examined for zinc. Generally along with such samples came fragments of other material, often the peculiarly shaped pyrite nodules, so abundant in the western part of the state. Occasionally a letter of inquiry would state that the samples had been assayed for zinc and had been shown to hold large quantities of the metal. In the latter part of 1896 it was

learned that the citizens over the territory mentioned, including part or all of Russell, Ellis and Trego counties, were becoming more or less interested in the stories outsiders were circulating to the effect that large quantities of zinc existed in different kinds of rock, sometimes even in the soil of the fields where crops of grain were grown. Reports of the negative results obtained by chemical examination of the specimens sent to the University seems to have had some effect in quieting such wild rumors.

It was explained, however, to the citizens of the country, that the zinc occurred in some peculiar form not familiar to the ordinary chemist or mineralogist, and that some special process of assay or chemical examination was necessary in order to detect its presence. The writer has the statement directly from a large property owner in Russell county, that parties visiting him walked out across his cornfield and picked up handfuls of the soil, stating that the very soil on which the crops were grown held fully fifty per cent. metallic zinc.

It was during the autumn of 1896 that the popular rumors regarding the existence of fabulous quantities of zinc were heard, since which time there has been much less said about the zinc. But about that time came the statement that gold existed in exceedingly large quantities in the same localities. There is a certain glamor about reported gold finds which carries with it a degree of enthusiasm rarely reached by any other discoveries. Assays were reported from many places, more than half of which were said to have been made by reliable assayers, and the amount of gold found sometimes reached over $300 per ton. One sample sent this department from Russell county was reported to be exactly similar to like samples sent elsewhere for examination. The other examination showed $140 gold and $40 silver to the ton. The sample sent here, though assayed with the greatest care, failed to give even a trace of gold or silver.

The failure on the part of the University assayers to find the desired metal has been explained variously by different parties, but all explanations in substance amount to a statement that the assay department of the University is not capable of making assays according to the latest methods for detecting gold in this peculiar kind of gangue material, especially when it occurs in the particular style of compound which is said to exist in western Kansas, a compound no one has yet named definitely nor isolated so that an examination of it could be made.

During 1896 and 1897 a considerable part of the discussion was

connected in some way with the so-called Beam process, by which it is claimed a larger amount of gold can be obtained from ore than by any other process. This Beam process has been so thoroughly exposed, particularly by as reliable a periodical as the *Engineering and Mining Journal*, of New York, in its issues of October 2, 1897, July 23, 1898, and May 20 and 27, 1899, that it would seem nothing further need be said on the subject.

The latest discussions are confined largely to reported assays said to have been made by Thomas A. Edison, with results so astonishingly large that, if correct, one would think no gold fields in the world have ever been operated which would at all compare in importance with those of western Kansas. From recent correspondence directly with Mr. Edison it is learned that such rumors are entirely erroneous, and that he found no trace of gold. Reports are current of scores of assays by many different assayers, from almost all over America, yielding gold from traces up to $300 or more per ton.

The material in which the gold is said to exist in the ordinary dark colored, fossiliferous, fine-grained Cretaceous shales so abundant in the Cretaceous area of Kansas and adjoining states. Many of the samples sent to the University seem to be nothing but the ordinary shale which exists, either at the surface or within a few hundred feet under ground. over fully one-third of the state. There is nothing about the shales to show any metamorphic action, or to imply that any eruptive action of any kind has ever taken place near them. From an extended study of the geology of that part of the state, it is positively known that the great mass of strata are lying undisturbed and entirely removed from any eruptive action of any kind, or from any vigorous dynamic action of any kind whatever. There is always a possibility, of course, of a local eruption of greater or lesser extent, or of a local disturbance similar to those so prominently represented in the great gold mining territories of the world. But thus far no one has ever been able to point out even a slight approach to such a condition.

Our disbelief, therefore, in the existence of any considerable quantity of gold in the so-called gold fields of Russell, Ellis and Trego counties may be attributed to two conditions. First, we can find no gold in the ores by assaying them, sixty cents to the ton being the largest yield ever yet obtained at the University, although nearly two hundred samples have been assayed. Second, the general character

of the country is such that it would be most remarkable should any considerable quantities of gold be found under similar conditions.

But western Kansas is not the only part of the state from which gold or silver has been reported. Samples from almost all parts of the state are frequently sent in, with statements that Mr. So-and-so, a reliable assayer, found so many ounces of gold or silver to the ton, a quantity sufficiently large to cause a very considerable excitement. Only a few years ago reports from Washington county were current to the effect of big finds of good gold ore, and of farmers being offered large sums for their lands, far above the normal value. But the reports proved to be incorrect, and few, if any, now believe gold ever was found there at all. During the latter part of May, 1899, samples were received from the southeastern part of the state—the locality being carefully withheld—with a report that some assayer, name not given, had found gold, or silver, or both, in each of a series of samples, the richest of which were forwarded here for examination. A careful fire assay was made, resulting in finding no trace of either metal in two of the four, while the other two yielded two-tenths and four-tenths ounce respectively of silver to the ton, an amount considerably smaller even than that reported nearly twenty years ago to have been found by different assayers in the limestones along the bluffs of the Kansas river in the vicinity of Argentine and Kansas City. Similar reported gold finds have reached us from Jewell county, from Baldwin and Clinton, in Douglas county, and from fully a dozen other places in the state, showing that there is an unusual feverishness of wide-spread extent. This cannot fail to work an injury to our state; for false hopes once raised blast true and proper ambitions, and unfit men for the ordinary duties of life.

Gold and Silver Smelting.

During the year 1898 the Consolidated Kansas City Smelting and Refining Company, at Argentine, did a business aggregating $13,000,000, as against more than $15,000,000 in 1897, and $16,500,000 in 1896. The principal reduction in output was confined to refined silver. The total value of the refined silver produced in 1898 was less than $5,000,000, while in 1897 it was more than $7,000,000, and in 1896 more than $15,000,000. The other products at Argentine, in general, increased. The total gold refined was the largest within the history of the refinery, aggregating more than $5,000,000. The copper ob-

tained was entirely changed into blue vitriol and sold in that form, aggregating more than $320,000 in value. The zinc likewise, used in the gold and silver refineries, was changed into white vitriol, reaching over $50,000 in value. During 1898, however, the lead was sold as metallic lead rather than as litharge, as was done in 1897, the total of the metallic lead being worth more than $3,000,000. Table II on page 18 shows the production of this plant for 1898, and also the total value of the several productions throughout the life period of the plant, the whole business aggregating the enormous sum of over $127,000,000.

TABLE II.

SHOWING THE OUTPUT OF THE ARGENTINE SMELTING AND REFINING COMPANY FOR 1898 AND FOR ENTIRE PERIOD OF OPERATION.

Gold and silver expressed in fine ounces; copper, blue vitriol and litharge in pounds, and lead in tons. Fractions omitted.

PRODUCT.	1898.			Total production during operation of plant.		
	Amount.	Coinage value.	Commercial value.	Amount.	Coinage value.	Commercial value.
Gold..................oz.	242,736.341	$5,029,804 95	$5,029,804 95	1,103,410.00	$22,809,508 35	$22,809,508 35
Silver..................oz.	7,889,029.46	10,199,726 19	4,595,359 66	117,743,515.00	139,301,590 54	70,367,658 63
Copper...............lbs.	....	....	....	*a* 9,000,000.00	....	990,000 00
Blue vitriol...........lbs.	9,846,312.000	....	344,620 92	*b* 11,013,833.00	....	357,949 14
White vitriol.........lbs.	291,011.000	....	50,926 93	*c* 291,011.00	....	5,820 22
Litharge.............lbs	....	....	....	*d* 2,881,124.00	....	112,353 00
Lead ....tons	39,946.26	....	2,900,098 51	446,778.93	....	32,962,802 25
Total values	....	$15,229,531 14	$12,920,810 97	....	$162,111,098 89	$127,401,938 67

a Production of 1894, 1895, and 1896. *b* Production since July 1, 1897.
c Production of 1898 only. *d* 1897 only.

II.—LEAD AND ZINC.[1]

THE year 1898 was the most prosperous year in connection with the various phases of lead and zinc mining and smelting ever known to our state. This is true not only of mining, but also of smelting.

LEAD ORE AND ZINC ORE MINING.

Galena District.

The territory covered by the mining operations of 1898 is practically the same as that of 1897. The Galena district, in general, expanded both north and south. The Jones prospects on the north side of the river near the state line have developed into very rich mines, which will probably result in the opening up of a new mining camp in that locality, the fortunes of which time alone will tell. From the general geologic conditions of the locality, however, everything would encourage future prospecting with a fair degree of hope of success.

On the south, mining operations have gradually been pushed across Shoal creek into the Tennessee Prairie district. It is hazardous to predict what results will finally be obtained in this region. It is, however, safe to say that no special geologic conditions are present which need discourage one from prospecting.

To the southwest of Galena mining operations have also been carried two or three miles farther. At the time of this writing (June, 1899) there are some excellent developments nearly two miles southwest of the famous Mastin land. Prospecting is now being prosecuted in this camp, with good indications of a remarkable development.

The Shawnee creek valley on the west of Spring river at the old Pitzer diggings had a short-lived revival during the summer of 1898. A company leased the ground and subleased to more than twenty in-

1. As our final report on lead and zinc will be completed during the next fiscal year, the discussion of this subject is made much briefer than it otherwise would be.

dividual miners, who began new shafts or opened up old ones which had been abandoned for years. The leasing company put in a large pump and gave assurance that they would be able to drain the valley to a workable depth. The pump ran in all about two months, during which time it readily kept the water down to a depth of from fifty to sixty feet at the pump shaft, and somewhat less further away.

The success the individual miners had in developing good prospects is quite remarkable. Almost every shaft that reached a depth of forty feet either obtained a fairly good paying ore or sufficient "shines" to justify believing good ore would be reached at a little greater depth. But the pumping shaft was not deepened, and the water was reached in most shafts at about forty feet. The prospectors not caring to try to beat the water themselves, became discouraged and quit, leaving the leasing company with nobody to work their grounds.

The rapid advance in the price of zinc ore near the close of 1898 greatly stimulated mining operations, increasing the value of the total output from about $2,250,000 in 1897 to $2,347,029 in 1898. The sharp increase in price began near the close of the year, and was carried on into 1899, with first-grade ore selling one week (from Belleville, Mo.) at fifty-five dollars a ton, a price entirely unprecedented, and considerable Kansas ore selling at fifty-one and fifty-two dollars.

The result of this high price was, that many outsiders were attracted to the zinc-mining districts, millions of outside money invested, and a district which for twenty years has already been the most active in mining operations of any within the state suddenly had this activity greatly increased. During the last week of August and the first week of September, this Survey listed every ore-dressing mill in the state. Since then, new mills have been built to so great an extent that it is probable the number has been almost doubled during the past nine months. The new mills are much better and larger than the old ones, and will do proportionally more work. Should the present activity continue during the remainder of 1899, the total output in tonnage and value for the year will be far greater than for 1898. One can hardly realize the activity in mine development and mill building the first four or five months of 1899 have witnessed. Properties which previously could be bought at a nominal figure suddenly increased two or three times in value. A mine which,

working night and day, can show a weekly output ranging from $2000 to $5000 is not uncommon. This has resulted in a much more systematic method of mining. In such mines the ground work is carried on with special reference to a large and regular tonnage, that the mills may be kept constantly in operation. Long and deep tunnels are driven, to develop as large a face of ore as possible, and everything is done to increase the rapidity with which ores of all grades may be produced, rather than the old-fashioned way of gouging here and there to obtain the richest streaks, regardless of the quantity of leaner ores which might have been taken out at the same time at but little additional expense. It is estimated that, with a modern mill, a rock which will average two and one-half per cent. of a high-grade, marketable ore can be handled at a profit. Many of the mills have spent a considerable time in working over the old piles of tailings and other refuse which formerly had been abandoned. This will be continued in the future should ore retain its present value. A low estimate would place the actual value of the refuse on top of the ground in Kansas territory at more than $1,000,000. Much refuse can be worked at a profit by proper handling, even should ore drop to thirty dollars a ton.

One of the greatest needs in the mining districts is the introduction of heavier machinery for more rapid work. There is scarcely a hoister in all the Galena-Joplin district that lifts more than 500 pounds at a time. They should be made to lift at least a ton. Likewise, the crushing and milling appliances are too small. If experience has proved that, by making the castings of the breakers longer and wider decreases their usefulness, then two or more breakers should be placed in one mill. The rolls should be increased in length and additional sections should be added to the jigs, so that the whole operation may be conducted on a much larger scale. The ordinary mill, which is called a hundred-ton mill, rarely handles more than fifty or seventy-five tons in a shift of ten hours. By increasing the size of the mill and the capacity of the hoisting apparatus, and the width and stability of the underground tramways, and the use of steam or compressed-air drills and other modern methods of blasting, the rough ore could be handled for approximately half what it now costs. This would make it possible to work correspondingly leaner ores, and so vastly increase the output of almost every piece of ground in the whole territory. It is one of the remarkable facts in connection with lead and zinc mining operations, that labor-saving appliances have been so sadly neglected. It is only

comparatively recently that first-class business methods have been adopted to any considerable extent, and even now there is scarcely a milling plant in the territory that is not susceptible of improvement. It is conceded, of course, that during the prospecting period crude and primitive methods are allowable because of their cheapness. So long as our mining territory continues to expand by prospecting, these methods will find a proper use along the outlying borders where the existence of large beds of ore has not yet been established. But where it is known that ore exists in quantity the prospecting stage is past, and the positive mining and milling operations should be conducted in the most approved manner known to the close of the nineteenth century.

Lead and Zinc Ores in Other Parts of the State.

During 1898 and early in 1899 interest has attached to the discoveries of small quantities of lead ore and zinc ore in other parts of the state. This subject was briefly discussed in our report for 1897[1], with a statement that frequent discoveries of zinc ore have been made in many places in the southeastern part of the state, reaching as far west as to Walnut and Erie. The recent discoveries have in general been similar to those previously described, but there is a zeal and interest manifested on the part of many citizens which it would seem is hardly warranted.

XENIA.

In November, 1898, near Xenia, in the northwest part of Bourbon county, zinc ore was found in small quantities, a company organized, large bodies of land leased, numerous dispatches published in various newspapers of the locality and the large dailies of Kansas City and Topeka, until an outsider would have been led to suspect the existence of a large quantity of ore. One dispatch quotes a miner as saying that he would be glad to take the ore obtained in sinking a shaft as his pay for the work—a statement which rarely if ever could have been made in connection with a shaft sunk in the Galena-Joplin district.

Here there is a little bit of history that is of interest, and may be given. Back in the seventies, it is reported, a farmer was digging a well, when he came upon a body of lead ore covering the greater part of the bottom of the well. This proved to be a body of pure lead ore six or eight inches thick. Considerable excitement was raised at the time,

1 Mineral Resources of Kansas, 1897, page 24.

and the farmer, not being experienced in mining, scarcely knew what to do. One "practical" miner from Joplin advised him to go deeper, while another "practical" miner from Colorado advised him to drift on the body of ore already found. He finally followed the advice of the Joplin miner, sank his well as deep as he could, and then drilled in the bottom of the well until a depth of about 200 feet was reached, without finding any more indications of lead ore. The operations were finally abandoned and the subject almost forgotten until the autumn of 1898, when the above-mentioned revival occurred. At this date it is impossible to say what the result will be. The local interest is still great, and many people confidently believe that a large body of ore exists in the vicinity.

PLEASANTON.

Early in 1899 a great interest was developed in Pleasanton by the discovery of lead ore and zinc ore in the walls of an old shaft which had been abandoned for years. And here likewise is an interesting story in connection with previous prospecting. When Linn county was first settled (in fact as early as 1858), one could observe indications of mining operations having been carried on along a little stream about two and a half miles southeast of Pleasanton. A number of small mounds, composed principally of debris of the Coal Measure shales, were noticed, supposed to have been produced by mining operations. It was found that these contained small fragments of lead ore, galena, which could be found in great numbers after a rain. The origin of these mounds and their history is entirely unknown. One of them as early as 1865 had growing on its summit on oak tree as much as six inches in diameter, which probably was then twenty or thirty years old.

The existence of lead ore in these little mounds created so great curiosity that a company was finally organized in 1873 and prospecting begun. Two or three shafts were sunk, one of them at least to a depth of 200 feet, and small pieces of ore were found, but nothing of any considerable importance. After the company spent what money it raised work was abandoned.

At various intervals during the past twenty-two years the mining operations were discussed and different parties expressed a firm belief in the existence of large quantities of ore. Nothing was done, however, until the spring of 1899, when companies were organized, grounds leased and subleased, and many prospecting shafts and drill holes begun. Some of the old shafts were opened and examined, and drifts

driven out at different levels, with the result that a few thousand pounds of high-grade lead ore and a small amount of zinc ore were obtained. The ore occurs in a soft shale, the Pleasanton shales. In most cases it is beautifully crystallized, affording magnificent museum specimens.

OTHER EASTERN KANSAS AREAS.

Throughout the year many other discoveries of small quantities of zinc ore have been made at a great variety of places in eastern Kansas. The most frequent finds are in connection with the Erie and Iola limestones, particularly in Linn, Franklin, Bourbon, Anderson, Allen, Neosho and Wilson counties. Even the Oread limestone, a few miles west of Lawrence, is found to contain zinc blende. Such discoveries are so wide-spread in geological extent and so frequent in occurrence that it need not be surprising to learn of similar discoveries at any time from almost any point in the eastern fourth of the state.

No encouragement can be given, however, for the belief in the existence of either zinc ore or lead ore throughout this region in sufficiently large quantities to make mining operations profitable. The general geological conditions in the Coal Measure areas of the state are such that it is exceedingly doubtful if large deposits of any kind of mineral products could have been formed. There is no mining region in the world where metalliferous ores have been segregated to any great extent that is not also one of great thickness of hard, firm rock. Ore deposits must be found in places where fractures and openings exist in the rock mass. If earthquakes and other earth movements have been sufficiently vigorous to break and fracture the rocks in a given area, one step has been taken in producing the essential conditions for ore deposition. If these rocks are hard and firm, so that the openings will remain open, allowing the free passage of water, ore deposition may occur. If, on the other hand, the rock mass is soft and yielding, such as the Coal Measure shales, the openings will not have been produced in them to so great an extent, and where produced soon become filled by the falling in of material from the sides, so that the free and abundant passage of water is prevented. This is well illustrated by the universal fact that heavy shale beds carry little water.

An examination of the general geologic conditions of the Coal Measure shales of Kansas reveals the fact that upon an average we have four feet of shale to one foot of limestone. This has been il-

lustrated and emphasized in Volume III of our University Geological Survey reports, and may be illustrated again by Plates I and II, republished in connection with oil and gas in this report.

The different shale beds in the Coal Measure area vary greatly in thickness, with a maximum of about 500 feet. If the earthquake movements which so effectively fractured the flint rocks in the Galena-Joplin area were as severe farther west these heavy shale beds would scarcely show the effects of such earth tremors, and were they sufficiently strong the actual fractures in the shale beds would remain open but a short time before they would be filled up. Therefore the openings produced in the limestones, which probably would be retained, would avail but little on account of the heavy shale beds above and below acting as barriers and rendering the free circulation of water impossible.

This department is now in possession of a few facts which have direct bearing on this question that may be mentioned in this connection, although no detailed publication has yet been made. In our study of the coal fields it was found that the "horsebacks" are far more abundant in Cherokee and Crawford counties than in the coal beds in other parts of the state. These "horsebacks" are simply the results of fractures in the coal, which fractures have been filled, principally from below, by fire-clay and other clay products being squeezed into the openings, as is fully explained in Volume III. The existence of fractures in such superior numbers in Cherokee and Crawford counties, in connection with the fact that they almost universally trend northeast or southwest, is most readily explained by associating their origin with the general earth movements which produced the Ozark uplift to the southeast.

It seems when this area was elevated earthquakes or similar movements fractured the rocks to a great extent, producing a peculiar and unusual set of openings throughout the whole Galena-Joplin mining district. In this district, however, the rocks are hard and firm to as great a depth as deep borings have been carried; that is, at least to 1000 feet. The openings, therefore, retained their form and made the circulation of water most easily accomplished. But passing westward into the Coal Measures the area is farther removed from the source of the fractures, and in addition it contains the heavy beds of shale, which of themselves probably would have prevented extensive ore depositions.

There are therefore two reasons for having greater faith in extensive ore deposition in areas now occupied by lead and zinc mining opera-

tions than in any other parts of eastern Kansas. Discoveries of ore probably will be made here and there in many new localities, and occasionally considerable amounts may be found in the most favorable positions. But it is the opinion of this department, based upon a tolerably detailed knowledge of the geological conditions of the whole eastern part of the state, that there will never be developed extensive metalliferous deposits in any of the rock formations variously associated with the Coal Measure shales.

WESTERN KANSAS AREA.

Reports still continue to be circulated regarding the existence of large quantities of zinc ore in the Cretaceous shale beds of western Kansas, particularly in Russell, Ellis and Trego counties, along the bluffs of the Smoky Hill river. A brief history of the events attending the development of the western Kansas gold and zinc mining enterprises is given in the chapter on gold and silver in this report. It should be stated, however, that no additional evidence regarding the presence of zinc in any form in the localities named has reached this department in the past year. More than fifty different samples reported to contain zinc have been carefully examined, not one of which contained even a trace of zinc. We are therefore in total ignorance regarding the existence of even a trace of any kind of zinc ore in either of the counties above named.

Ore and Spelter Markets and Ore Output.

The zinc ore markets for 1898 averaged the best ever known in the history of mining in Kansas. The average price per ton for top-grade ore was nearly twenty-eight dollars, while for the whole output it was, according to Elliott's estimate $26.64, and $28.44 according to the estimate of the Joplin special correspondent in the *Engineering and Mining Journal*, an estimate evidently too high. This is more than one dollar a ton higher than ever before known. In the early part of the year the price was little if any higher than in 1897. By the middle of May a decided advance was noticed, the best ore bringing twenty-seven dollars. The price gradually increased with few reversals up to the middle of December, when tops brought forty dollars per ton, after which there was a slight decrease to the close of the year. The price soon rallied again, so that during the first third of 1899 it has been by far the highest ever known, having reached a maximum of fifty-five dollars.

About the 1st of January, 1899, the ore producers of the Galena-

TABLE III.

SHOWING PRICE PER TON OF ZINC BLENDE AT GALENA-JOPLIN,

From 1886 to 1898, inclusive, and price per ton of metallic zinc in New York, with ratio between the two; also price per ton of metallic zinc in sixty-per-cent. zinc ore and difference between this and New York price.

YEAR.	Price per ton of zinc blende in Galena-Joplin. (2000 lbs.)	Price per ton of metallic zinc in New York. (2000 lbs.)	Ratio between price of zinc blende and metallic zinc.	Price per ton of metallic zinc in 60-per-cent. ore. (2000 lbs.)	Difference between price per ton of zinc in 60-per-cent. ore and New York price.
1886	$18 50	$87 90	1:4.69	$30 83	$57 07
1887	19 00	92 80	1:4.88	31 67	61 13
1888	21 00	98 34	1:4.68	35 00	63 34
1889	24 00	100 20	1:4.17	40 00	60 20
1890	23 00	108 75	1:4.72	38 33	70 42
1891	21 51	108 82	1:5.05	35 85	72 97
1892	20 00	89 78	1:4.48	33 33	56 45
1893	18 85	80 37½	1:4.28	31 42	48 95
1894	17 10	70 43	1:4.09	28 17	41 26
1895	19 68	71 04	1:3.60	32 80	38 24
1896	22 51	79 70	1:3.54	37 45	42 25
1897	25 17	82 40	1:3.27	41 82	40 58
1898	27 63	91 40	1:3.30	46 05	45 35
Averages..	$21 38	$89 37	1:4.21	$36 38	$53 79

TABLE IV.

SHOWING MONTHLY PRICE OF ORE AND METALLIC ZINC,

With ratio between same, and price per ton of zinc in sixty-per-cent. ore, and difference between this and New York price, 1898.

MONTH, 1898.	Price of zinc blende per ton, Galena-Joplin. (2000 pounds.)	Price of metallic zinc per ton, New York. (2000 pounds.)	Ratio between price of zinc blende and metallic zinc.	Price per ton of metallic zinc in 60-per-cent. ore. (2000 pounds.)	Difference between price per ton of zinc in 60-per-cent. ore and New York price.
January	$23 60	$79 20	1:3.35	$39 33⅓	$39 87
February....	22 95½	80 80	1:3.52	38 26	42 54
March	22 33	85 00	1:3.80	37 22	47 78
April	24 18	85 20	1:3.52	40 30	44 90
May	25 37½	85 40	1:3.36	42 29	43 11
June........	27 03	95 40	1:3.52	45 05	50 33
July	26 78½	93 20	1:3.46	44 64	48 56
August	26 80	91 60	1:3.41	44 66	46 94
September..	29 80	93 40	1:3.31	49 66	43 74
October.....	31 56½	99 60	1:3.15	52 61	46 99
November...	35 87½	105 80	1:2.94	59 79	46 01
December...	37 01	102 00	1:2.76	61 70	40 30

Joplin district effected an organization for the purpose of maintaining the price of zinc ore. They send out weekly statements regarding what the price of ore should be for the week, attempting, it is claimed, to base this price on the price of spelter in St. Louis and on the grade of ore. With spelter selling in St. Louis at $6.75 a hundred, they claim a zinc ore assaying sixty per cent. metallic zinc should bring about forty-seven dollars a ton, and that with the variations in price the ore price should likewise vary.

One cause for the existence of such an ore-producers' organization, it is claimed, is that previously there was no very close relation between the price of spelter and the price of ore. It is therefore interesting to look into this matter. The following table III gives an exhibition of these conditions, showing the average price of ore from 1886 to 1898, inclusive, and the price of spelter in New York for the same years. A more detailed statement of the price for 1898 may be interesting. Table IV is a statement of the monthly price of ore at the Galena-Joplin mines and of spelter in New York city.

It will be seen that the ratio between the price of ore and of spelter has not been very constant, the greatest difference being in 1891, when it took 5.05 tons of high-grade ore to bring the price of one ton of spelter in New York. From that date to the present the ratio gradually changed, until in 1898 it required but 3.3 tons of high-grade ore to bring the price of one ton of spelter.

An examination of table IV is interesting on account of its showing the monthly conditions during 1898, the year in which the most rapid changes took place of any year in our history. It will be seen that the price of ore did not advance quite as rapidly as the price of spelter until August, after which it rose more rapidly, finally forcing the ratio down, until in December but 2.76 tons of ore were required to equal in price one ton of spelter in New York.

The principal source of statistics regarding ore production in the Galena-Joplin district is the records in the freight offices regarding shipment of cars. The Joplin correspondent of the *Engineering and Mining Journal* sends a weekly statement of the output to that journal. His sources of information are, in the main, the records in the freight offices. In Galena, at present, the Galena *Times* and a few private individuals gather figures which, in the main, correspond with those published in the *Engineering and Mining Journal*, but differ slightly in some details. Of the private statistics, it is probable those gathered by Mr. Russell Elliott, of the Galena mining bureau, are as

TABLE V.

SHOWING AMOUNT AND VALUE OF ZINC ORE AND LEAD ORE IN THE GALENA AREA
compared with amount and value of same ores for the whole Galena-Joplin area, 1898.

(Data gathered from reports of Joplin correspondent in *Engineering and Mining Journal*.)

Month.	Product and value of Kansas area in 1898.					Product and value of Kansas and Missouri area in 1898.					Per cent. Kansas production is of whole area, 1898.	
	Zinc ore. In tons (2,000 lbs.) and dollars.		Lead ore. In 1,000 lbs. and dollars.		Total value.	Zinc ore. In tons (2,000 lbs.) and dollars.		Lead ore. In 1,000 lbs. and dollars.		Total value.		
	Product.	Price.	Product.	Price.		Product.	Price.	Product.	Price.		Zinc ore.	Lead ore.
January	5,590.00	$23 25	1,627.22	$22 00	$153,813	15,342.05	$23 25	4,680.83	$22 00	$420,636	36.43	34.76
February	6,035.00	22 62	1,685.27	21 75	161,537	16,052.95	22 62	4,645.53	21 75	430,543	37.58	36.27
March	6,610.00	22 50	1,532.26	23 12	174,131	18,374.68	22 50	4,625.73	23 12	485,467	35.96	33.14
April	7,648.72	27 30	1,447.19	21 60	208,502	20,875.49	27 30	4,945.39	21 60	592,995	37.22	29.26
May	5,542.95	25 50	1,184.71	21 75	157,580	16,541.89	25 50	3,983.11	21 75	459,639	33.50	29.74
June	6,397.38	28 00	1,506.51	22 37	182,712	17,481.36	28 00	4,720.20	22 37	543,574	36.59	31.91
July	6,773.90	27 90	1,514.54	22 60	208,411	20,738.07	27 90	5,127.88	22 60	663,242	32.66	29.53
August	5,430.55	27 00	1,514.65	23 06	166,855	17,000.40	27 00	3,783.83	23 06	521,325	31.94	40.02
September	5,038.02	30 50	1,000.18	23 50	165,343	16,692.49	30 50	2,708.84	23 50	557,001	30.18	36.92
October	7,282.58	24 40	1,203.01	23 45	239,755	23,669.92	24 40	3,406.14	23 45	777,836	30.76	35.31
November	6,038.86	34 75	983.99	21 08	308,711	20,424.32	34 75	3,529.79	21 08	706,395	29.56	27.87
December	5,778.59	36 10	998.92	20 00	209,014	21,296.09	36 10	3,726.36	20 00	611,485	27.13	26.80
Totals and averages	74,166.65	$27 635	15,199.45	$22 177	$2,236,364	224,689.71	$27 635	49,883.63	$22 177	$7,770,138	33.28	32.63

reliable as any. In our report on "Mineral Resources of Kansas for 1897," page 31, is given a table showing the output and price per ton and total value of ores from Galena from 1886 to 1897, nearly all of which was gathered from Mr. Elliott's tables. It is thought desirable this year to publish the figures gathered from the *Engineering and Mining Journal*, and, for comparison, those of Mr. Elliott.

Table V is compiled from the *Engineering and Mining Journal*, showing the output and value, (*a*), of the Galena district; (*b*), of the whole Galena-Joplin district, and (*c*), the per cent. of the total production credited to Kansas. Table VI is copied from a table kindly sent in by Mr. Russell Elliott, of Galena. It will be seen that there is a slight difference between them, but when properly compared they are essentially the same. The price per ton in table V is an average of the weekly prices quoted, and generally refers to top prices, but not always so. The price per ton given by Mr. Elliott in table VI is obtained by dividing the total value of ore by the number of units sold, and therefore is the average for Galena.

Table VII shows the annual output of ore from Galena, with the aggregate value; also estimate from the time mining began.

TABLE VI.

SHOWING THE MONTHLY OUTPUT OF ZINC ORE AND LEAD ORE FROM THE GALENA AREA DURING 1898, WITH VALUE OF SAME.

Private figures, by Mr. Russell Elliott, Galena.

MONTH.	Pounds zinc ore.	Price per ton 2000 lbs.	Value.	Pounds lead ore.	Price per 1000 lbs.	Value.	Total value.
January...	11,530,000	$24 25	$129,440 25	1,463,390	$21 75	$31,828 75	$161,269 00
February..	11,059,800	23 41	129,501 55	1,413,110	22 23	31,441 45	160,943 00
March.....	12,858,440	21 65	139,118 95	1,434,580	22 50	32,278 05	171,397 00
April......	14,998,970	23 74	178,087 35	1,529,240	21 50	32,878 65	210,966 00
May	11,583,490	24 25	140,489 55	1,156,620	21 75	25,156 45	165,646 00
June......	11,589,310	25 56	145,804 95	1,522,860	22 71	34,645 05	180,450 00
July.......	13,472,790	25 57	172,248 20	1,434,120	23 49	33,701 80	205,950 00
August ...	11,945,240	25 24	149,555 75	1,524,350	23 50	35,822 25	185,378 00
September,	10,223,210	28 60	146,250 75	894,980	24 39	20,808 25	167,059 00
October ...	14,985,050	29 43	220,368 05	1,195,090	21 99	26,291 95	246,660 00
November..	18,245,100	35 50	217,254 55	1,017,070	20 99	21,358 45	238,613 00
December..	12,213,300	37 02	226,110 65	1,251,170	21 25	26,587 35	252,698 00
1898.....	149,704,700	$27 02	$994,230 55	15,836,570	$22 33	$352,798 45	$2,347,029 00

TABLE VII.

SHOWING OUTPUT OF ZINC AND LEAD ORES, GALENA DISTRICT, KANSAS.

From January 1, 1886, to December 31, 1898, inclusive. (Data for 1896 and 1897 from the *Engineering and Mining Journal;* all others from Mr. Russell Elliott, Galena.)

YEAR.	ZINC ORE.			LEAD ORE.			Total value of output.
	Tons, 2000 lbs.	Average price per ton.	Value.	Pounds.	Average price per 1000 lbs.	Value.	
1886 ..	81,768	$18 50	$587,708 00	5,921,284	$29 50	$174,766 38	$762,474 38
1887 ..	32,795	19 00	623,105 00	6,152,380	26 25	161,499 98	784,604 98
1888 ..	33,391	21 00	701,211 00	5,248,000	15 50	81,344 00	782,555 00
1889 ..	32,950	24 00	790,800 00	7,9:5,000	23 00	183,655 00	974,455 00
1890 ..	21,675	23 00	498,525 00	8,347,927	21 14	176,176 28	674,701 28
1891 ..	20,641	21 51	454,102 00	7,204,420	25 16	182,271 83	636,373 83
1892 ..	23,811	20 00	476,237 78	14,376,340	21 00	301,903 14	778,140 92
1893 ..	25,028	18 85	471,789 00	10,279,180	19 00	195,314 42	667,103 42
1894 ..	28,670	17 10	490,257 00	11,634,980	16 82	195,794 66	686,051 66
1895 ..	41,232	19 68	812,792 00	25,075,290	19 28	482,548 75	1,295,340 75
1896 ..	62,232	22 51	1,401,307 83	28,123,170	16 02	450,529 90	1,851,837 73
1897 ..	59,451	25 17	1,492,663.04	30,369,360	25 10	762,469 96	2,255,133 00
1898 ..	74,852	26 64	1,994,230 55	15,836,570	21 02	352,798 45	2,347,029 00
Totals,	483,496	....	$10,794,728 20	176,566,901	....	$3,701,072 78	$14,495,800 95

Estimated total production of ore from 1876 to 1898, inclusive, $27,347,029.

Mr. Elliott obtained value per ton of zinc ore and per 1000 of lead ore by dividing value of sales by number of tons and of thousands. In table V, copied from the *Engineering and Mining Journal*, the value per ton and per thousand was obtained by averaging the weekly prices as given by the Joplin correspondent, which generally referred to top prices.

World's Production of Zinc.

For years past, and particularly during the last few months, there has been a great deal of talk in the mining districts regarding a decrease in the foreign output of metallic zinc. Some enthusiasts have even stated that the foreign output has declined so rapidly that the Galina-Joplin district now produces about forty per cent. of the metallic zinc of the world. It is therefore interesting to look into the statistics of the subject and to determine to what extent the American production may influence the markets of the world. Table VIII, which is for the years 1884 to 1898, inclusive, was prepared with this in view. It shows the total foreign production by countries, grouped as follows: The Rhine district and Belgium, Silesia, Great Britain, France and Spain, Austria, and Poland, to which is added the American output, and a final column gives the per cent. the American output is of the whole.

TABLE VIII.

SHOWING WORLD'S PRODUCTION OF METALLIC ZINC FROM 1884 TO 1898, INCLUSIVE.

(From Nineteenth Annual Report Director United States Geological Survey, part VI, pp. 223 and 284; foreign figures reported by Henry M. Merton & Co., London, England. Figures for 1898 from *Engineering and Mining Journal.*)

YEAR.	Rhine district and Belgium.	Silesia.	Great Britain.	France and Spain.	Austria.	Poland.	Total foreign.	America.	Grand total.	Per cent. American.
1898	191,836	99,233	27,635	32,649	7,229	5,664	364,246	103,515	467,761	22.10
1897	184,455	94,045	23,430	32,120	8,185	5,760	347,995	89,268	437,263	20.41
1896	179,730	95,875	25,880	28,450	9,255	6,165	345,355	72,767	418,122	17.43
1895	172,135	93,620	29,495	22,895	8,355	4,960	331,460	80,077	411,537	19.45
1894	152,420	91,145	32,065	21,245	8,580	5,015	310,470	67,257	377,727	17.80
1893	149,750	90,310	28,375	20,585	7,560	4,530	301,110	70,385	371,495	18.93
1892	143,305	87,760	30,310	18,662	5,020	4,270	289,327	77,910	367,237	21.21
1891	139,695	87,080	29,410	18,360	6,440	3,760	284,745	72,208	356,953	20.22
1890	137,630	87,475	29,145	18,240	7,135	3,620	283,245	57,860	341,105	16.96
1889	134,648	85,665	30,806	16,785	6,330	3,026	277,248	52,553	329,801	16.23
1888	133,245	83,375	26,783	16,140	4,977	3,785	268,305	49,913	318,218	15.68
1887	130,995	81,375	19,839	16,028	5,388	3,580	257,155	44,946	302,101	14.87
1886	129,020	81,630	21,230	15,305	5,000	4,145	256,330	38,072	294,402	12.93
1885	129,754	79,623	24,299	14,847	5,610	5,019	259,152	36,329	292,659	8.05
1884	127,240	76,116	29,259	15,341	6,170	4,164	260,290	34,414	294,704	8.56

A careful study of this table reveals many interesting facts regarding the variations therein. Of most importance, perhaps, is the interesting fact that the total foreign output has gradually increased throughout almost the entire period. The years 1886 and 1887 showed a slight decrease, but from that time to the present there has been a steady and marked increase in the total foreign production up to and including the year 1898, at which time there was a foreign production of 364,235 long tons of metallic zinc, an amount far greater than ever produced before.

An analysis of the figures from the several countries is likewise interesting. It will be seen that the Rhine district and Belgium is much the larger producer, their output equaling more than half the foreign production. With the exception of an insignificant reversal in 1886, this district has steadily increased its output from 1884 to the present time. During that year it produced 127,240 tons of spelter, and in 1898, 191,836.

Silesia has been a constant producer, ranging from a little over 76,000 tons in 1884 to more than 99,000 tons in 1898.

The output of Great Britain has varied more than either of the two countries just named, and on the whole has no more than held her own during the fourteen year period. In 1884 she produced a little over 29,000 tons; ten years later she reached the maximum of 32,000 tons; she dropped to 23,000 tons in 1897, and rallied to over 27,000 in 1898.

France and Spain have made the most marked increase of any of the foreign countries. In 1884 they produced but little over 15,000 tons; the following year there was a slight falling off, which was regained in 1886, from which time they have gained steadily, until in 1898 their combined production was more than 32,000 tons, barely surpassing the greatest output of Great Britain for the last fourteen years.

Austria and Poland have little more than held their own, the former producing from 6000 to 7000 tons, and the latter from 4000 to 5000.

During this period of fourteen years the American output has increased more rapidly than the foreign. In 1884 we produced a little over 34,000 tons, which equaled about 8.56 per cent. of the world's production. From that date we rapidly increased, until in 1891 we produced nearly 88,000 tons, or more than 21 per cent. of the world's

production. Our production then declined two years while the foreign production pressed steadily onward. In 1897 our production was more than 89,000 tons, which was over two and one-half times our output in 1884, but the world's production had increased so rapidly that this large amount only equaled a little over 20 per cent. of the total.

It will be seen from the foregoing table that while the output of American mines and smelters has been on the whole rapidly increasing, during the last eight years it has done little more than retain the relative rank which it gained in 1891 and 1892. The reports, therefore, that the foreign output of spelter has been rapidly falling off, thereby causing unprecedented advances in prices during the last twelve months, must be looked upon as entirely erroneous.

From every consideration the American should be pleased that such is not the case. Let us consider the question. If we were producing 50 per cent of the world's output at any one period and should by some good fortune double our production, the actual increase would be so great that it would seriously affect the markets of the world. If, on the other hand, we are producing only 15 or 20 per cent. of the world's output and could be able to double our production the world's spelter would be increased so slightly that the markets would be scarcely affected. If, therefore, it is a fact that the American mines are unusually productive during 1898 and 1899 our small per cent. of the world's production is a guaranty that we may carry our mining operations to any degree of increased production without much fear of unbalancing the world's markets until our per cent. of production is far ahead of what it has yet been.

The unusually high prices which have ruled for the past few months probably are principally due to the enormously increased demand for spelter for use in the mechanic arts, which in turn is largely dependent on the general revival of prosperity the world over. In this connection it may be interesting to quote the following discussions on the spelter market in New York and London from the *Engineering Journal* of January 7, 1899, page 21.

The New York Spelter Market in 1898.

"The course of the spelter market during 1898 has been exactly the reverse of that of 1897. Then the attempt made by a combination of some Western smelters to hold the market up by artificial means, such as the holding back of large quantities and the exporting of round

lots at ten and twelve per cent. below the domestic price, proved futile. This year the market has, notwithstanding an increase of fully twenty per cent. in the production, advanced beyond all previous limits. This has been due primarily to the tremendous consumption in this country. The wire industry absorbed more spelter than ever before, and the exports of galvanized wire have largely increased. Galvanizers of iron sheets have also done a larger business, though the margins in this line have been unsatisfactory. The brass consumption has been enormous and that of sheet zinc as large as before.

"Exports of spelter have been about the same as last year, but, unlike last year, the sales of spelter for export were not made at a sacrifice, but placed at top prices. It was the European demand that, at the end of the summer, when the consumption here was very large, developed the strength of this market. In spite of the fact that the spelter sold at unprecedentedly high figures during this year, complaints were heard that smelters were not able to secure a fair margin, owing to ore prices being driven up to unremunerative figures under strong competitive buying. Some of the older works in the coal belt were not operated. However, this was counterbalanced by the erection of new works in the gas fields of Kansas.

"In January the market ruled dull, and not until the end of February was there any perceptible increase in the demand. Then, however, and through March and the first part of April, the market steadily improved, reaching 4.10*c.* St. Louis, 4.30*c.* New York, and £18 12*s.* 6*d.* abroad.

"The end of April and early in May the demand fell off, buyers having covered their wants; and at the increased rate of production stocks quickly accumulated and the market became weak. However, consumption continued to expand, stocks were soon depleted, and the demands at the end of May and in June were simply enormous. At this juncture the burning of one of the refining plants increased the already acute scarcity of spot and near-by metal, and prices advanced rapidly to 4¾ @ 5*c.* St. Louis and 5⅛*c.* New York. The European market had meanwhile risen steadily and had reached £19 8*s.* 9*d.*

"In July buyers, having bought more than their requirements, held off, and a reaction set in, the metal selling down to 4.35*c.* at St. Louis and 4.50*c.* at New York. In August some sales were made at 4.25*c.* and 4.40*c.*, respectively, but again stocks in the hands of manufacturers had been used up, and, with liberal buying, the market turned and continued to advance with few reactions until toward the end of

TABLE IX.

SHOWING AVERAGE MONTHLY AND YEARLY PRICE OF METALLIC ZINC—"SPELTER"—IN NEW YORK FOR 1893 TO 1898, INCLUSIVE.

(From *Engineering and Mining Journal*, January 7, 1899, page 21.)

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	cts.	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*
1893	4.39	4.39	4.28	4.38	4.41	4.27	4.13	3.89	3.69	3.68	3.65	3.80	**4.08**
1894	3.56	3.85	3.89	3.62	3.47	3.40	3.43	3.38	3.44	3.45	3.36	3.43	**3.52**
1895	3.28	3.20	3.23	3.30	3.50	3.65	3.75	4.15	4.30	4.10	3.55	3.49	**3.63**
1896	3.75	4.03	4.20	4.09	3.98	4.10	3.97	3.76	3.60	3.72	3.99	4.14	**3.94**
1897	3.91	4.02	4.12	4.13	4.21	4.21	4.32	4.26	4.18	4.17	4.03	3.89	**4.12**
1898	3.96	4.04	4.25	4.26	4.27	4.77	4.66	4.58	4.67	4.98	5.29	5.10	**4.57**
Av. for the 6 years,	**3.81**	**3.92**	**3.99**	**3.96**	**3.97**	**4.07**	**4.02**	**4.00**	**3.98**	**4.02**	**3.98**	**3.97**	**3.98**
First half of 1899	5.34	6.28	6.31	6.67	6.88	5.98							

the year. In Europe there was a great scarcity of metal, due to the decreased output in the large Silesian mines, and the market at the end of September was £22, while here it was 4.70*c*. at St. Louis and 4.90*c*. at New York.

"In October and November foreigners were forced to purchase round quantities in this country, both for prompt and future shipment, and, with the increasing consumption on this side, the metal became exceedingly scarce. The miners were constantly advancing their prices for ore, until $40 per ton—an unprecedentedly high price—was paid.

"In November the advance culminated with New York selling at 5.40*c*., St. Louis at 5.22½*c*., and London at £24 15*s*."

The London Spelter Market in 1898.

By Our Special Correspondent.

"The market opened quiet but firm in January last, with ordinaries quoted at £18 to £18 2*s*. 6*d*., and special brands at £18 2*s*. 6*d*. to £18 5*s*., but after consumers had bought freely at these figures, the tone became easier and prices declined about a half crown or so. February opened quiet at £17 7*s*. 6*d*. to £18 for ordinaries, and the tendency was dull thereat. For the first two weeks of the month the Continental makers would not meet the market, and the Americans were decidedly higher in their views; buyers had consequently to meet the higher rates asked, and the price improved to $18 2*s*. 6*d*. and £18 5*s*.

"When March came in it was found that the continental producers had sold out for some months ahead, and in America there was such a good home demand that better prices could be obtained on their own side. Values in our market consequently stiffened, with buyers of ordinaries at £18 8*s*. 9*d*. April commenced with the scarcity of sellers more pronounced, and most of the dealers were sold out. Values continued to advance almost daily, and as consumers did not believe in the reported scarcity, they only bought quite sparingly; nevertheless, before the month was out ordinaries were worth £19.

"May saw a further advance on the continent, and large lines were sold at good prices. Consumers on this side, being temporarily covered, abstained from making fresh purchases, and the market went dull. This state lasted only for a short period, and the price again rose to £19 5*s*., which was the figure ruling at the commencement of June. Towards the middle of the month large purchases were again made on the continent, and that restricted the quantity for this market.

America was still practically out of the market, and remained only a passive factor until well into the last quarter of the year. Prices in the United States at this time took a sudden jump, and shippers bought back parcels sold for shipment to this country. This was immediately reflected on the English market, and prices commenced to soar upwards, and ere the month was over there were eager buyers at £20 for ordinaries.

"July opened with consumers showing considerable anxiety to cover themselves against sales of manufactured stuff, and they readily paid the advancing prices; £20 7*s.* 6*d.* was reached before any break occurred, but then some second-hand holders showed rather an inclination to make sales for forward delivery, and a retrogade movement was made to £20. August witnessed another steady rise, and it became apparent, rose to £20 12*s.* 6*d.*, with stocks on the continent standing at a severely low level.

"September found buyers very short of supplies for delivery over the remaining months of 1898, and they came in and bought with rather more pluck, and prices advanced quickly to £22. There was then a halt, but October was to be a month of surprises, and after a few holders of second-hand lots had sold at a sacrifice and weakened the market, the consumptive demand grew keener than ever, and prices rose at almost every sale until the end of the month the nearest price was £24 for ordinaries, special brands fetching 5*s.* per ton more. Very little spelter was offered at the commencement of November, and the continental makers had sold for a long time ahead. Spot stuff was very scarce, and there were then reports of American offers, and this frightened some London dealers, who sold down for £24. This level attracted buyers, and £24 10*s.* was again established; but when December came in consumers were very reserved, and it was difficult to make sales. Buyers deeming it better to hold off until after Christmas, prices therefore dwindled gradually to £23 5*s.* to £23 10*s.* for ordinaries, £23 10*s.* to £23 15*s.* for specials."

ZINC SMELTING.

During the year 1898 the Kansas zinc smelters produced the largest amount of spelter in the history of the state. This is due principally to the increased number of smelters. With the establishment of the smelters in the natural-gas region the total capacity of Kansas smelters was nearly doubled. Those using natural gas are: The Robert Lanyon's Sons Smelting Company, at Iola, with a capac-

ity of 2400 retorts; the W. & J. Lanyon smelter, at Iola, with 1800 retorts; the Nicholson smelter, at Iola, began operations in 1899 with a capacity of 1200 retorts; the Robert Lanyon's Sons smelter, at La Harpe, which had a few of the furnaces started before the close of 1898, will have a capacity of 3000 retorts when completed. At Gas City the Cherokee Lanyon Company are building a small furnace of 300 retorts; Messrs. Daly and McRay have a furnace of —— retorts, each of which began operations in 1899. At Cherryvale the Edgar Zinc Company began building a large smelter of 1800-retorts capacity, using the patented Brown horseshoe roasting furnace. The year 1899 will therefore have about 12,000 retorts heated by gas in the furnaces already completed or under construction, as against approximately 9000 retorts of the coal furnaces of the state.

Table X shows the amount of metallic zinc produced by Kansas smelters per annum from 1882 to 1898 inclusive. It will be noted

TABLE X.

SHOWING AMOUNT AND VALUE OF METALLIC ZINC PRODUCED AT KANSAS SMELTERS, 1882 TO 1898, INCLUSIVE.

Price per ton in New York.
(Data 1882 to 1896 from United States Geological Survey statistics.)

YEAR.	Amount in short tons. (2000 pounds.)	Price per ton in New York.	Total value.
1882	7,366	$110 60	$814,679 60
1883	9,010	90 60	816,306 00
1884	7,859	89 60	704,466 40
1885	8,502	86 80	737,973 60
1886	8,932	87 90	785,122 80
1887	11,955	92 80	1,109,424 00
1888	10,432	98 34	1,025,902 88
1889	13,658	100 20	1,368,531 60
1890	15,199	108 75	1,652,891 25
1891	22,747	108 82	2,475,336 96
1892	24,715	89 78	2,218,912 70
1893	22,815	80 37½	1,733,755 63
1894	25,588	70 43	1,902,162 84
1895	25,775	71 04	1,831,056 00
1896	20,759	79 70	1,653,592 30
1897	33,443	82 40	2,755,703 20
1898	38,543	91 40	3,508,524 27
Totals for 17 years..	307,298	....	$27,093,342 03
Estimation of zinc smelted previous to 1882			2,575,000 00
Total			$29,668,342 03

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that the total output is 38,543 tons, an amount more than 5000 tons greater than ever before produced in one year. This makes an aggregate of more than 300,000 tons produced in seventeen years, with a New York value of nearly $27,000,000. If we add to this a value of $2,575,000, an estimate for the spelter produced in the state previous to 1882, we have an aggregate of more than $29,500,000 worth of spelter produced on Kansas soil.

TIONS; A

E.

1895.
$75,000
1,013,612
1,517,936
5,000
364,900
40,750
....
....
....
34,200
....
10,050
5,850
6,000
8,100
3,900
1,850
462,313
11,250
11,250
6,000
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3,880
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3,590,141

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1895.
$75,000
1,013,612
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3,880
1,800
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that the total output is 38,543 tons, an amount more than 5000 tons

III.—COAL.

THE year 1898 was a prosperous year for the coal operators of Kansas. The total output, according to statistics kindly furnished in advance of publication by the State Inspector of Coal Mines, Hon. Geo. T. McGrath, was the largest ever produced in the history of the state, aggregating 4,193,159.7 tons. The prices for the year have been low; the lowest ever known except in the years 1896 and 1897. This cuts the aggregate value of the coal to figures a little below that of 1894, in which year the total value of the production exceeded that of any other year. It is estimated in value at $1.085 per ton at the mine for all kinds of coal. The values in the western part of the state, of course, are much higher, but the output in such localities is so small the aggregate value is hardly affected by it.

The most marked characteristic of the output for the past year is in the large amount produced in Cherokee and Crawford counties as compared with previous years. This is in keeping with the tendencies for years past, as is exhibited in table III, opposite page 192 of Volume III, University Geological Survey of Kansas, reproduced here as table XI for reference. According to that table, the output for Cherokee county had gradually increased from 1885 to 1897, inclusive, with but few exceptions. In 1897 this county produced 1,061,409 tons, while in 1898 the product was increased to 1,309,868 tons, an increase of about nineteen per cent. over 1897. Crawford county likewise has had a gradual increase with but few reversals from 1885. In 1897 it produced 1,590,620 tons, while in 1898 it produced 1,989,157 tons, an increase of more than twenty-five per cent. over the preceding year.

The principal falling off in the coal production has been in Osage county, although Leavenworth county likewise has decreased to some extent. In 1897 Leavenworth county produced 367,141 tons, while in 1898 the output was 305,316 tons. Osage county produced a maximum amount of coal in 1889, at which time it aggregated 446,018 tons. From this the output vacillated considerably and in general decreased,

until in 1897 it equaled only 181,857 tons, and in 1898 but 179,070 tons. The smaller producing counties, such as Coffey, Franklin, Labette, Bourbon, Linn, and the counties producing the brown coal from the west, have been gradually decreasing in their tonnage production for years, a decrease which was still maintained during 1898.

A consideration of the geological horizon from which coal comes is of interest. Table XI gives the tonnage and estimated value of the coal produced from the several geological horizons for 1890 to 1898, inclusive. According to this table the Cherokee shales have produced by far the greater production of the Kansas coals, with the Osage shales next in importance. A glance at this table will show that in general the percentage for the Cherokee shales has increased from 1890, at which time they produced over 77 per cent., while in 1897 they produced over 93 per cent., and in 1898 this increase was carried to 94.14 per cent.

The Osage shales are next in richness so far as the coal output implies. In 1891 they produced nearly thirteen per cent. of the total output of the state. From these figures there was a gradual decrease, until in 1897 they produced a little less than six per cent. of the total output of the state, while in 1898 the per cent. was 4.67.

The other shale beds have produced so small a proportion of the output of the state that they are hardly worth consideration. The fact so often stated previously is still apparent, namely, that the Pleasanton, Thayer and Lawrence shales contain large quantities of coal which may be brought onto the market at any time the price of coal advances only a small proportion.

The reason for this unequal production of coal in the state is very apparent. The Cherokee shales contain the thickest coal seams, and hence they are the most profitable to work; and in addition the coal produced from them is better in quality than that produced anywhere else in the state. In fact the coal from Cherokee and Crawford counties is of so high a grade that it compares favorably with the *best* bituminous coal in other parts of America.

The value of the coal at the mine for the past year was but little greater per ton than in 1897. The figures obtained from the State Inspector of Coal Mines, as above mentioned, show an average for the whole state of only $1.085 per ton, while the value for Cherokee and Crawford counties was but $1.05 per ton.

The common rate to the trade throughout both these counties during almost the entire year was $1.35 per ton for lump coal. When

TABLE XII.

SHOWING COAL PRODUCTION IN SHORT TONS (2,000 LBS.), 1880 TO 1898, INCLUSIVE.

With price per ton and value of yearly product.

YEAR.	Production in short tons (2,000 pounds).	Price per ton.	Value of yearly product.
1880*	550,000	$1 30	$715,000
1881*	750,000	1 35	1,012,300
1882*	750,000	1 30	975,000
1883*	900,000	1 28	1,152,000
1884*	1,100,000	1 25	1,375,000
1885	1,440,057	1 23	1,770,270
1886	1,350,000	1 20	1,620,000
1887	1,570,079	1 40	2,198,110
1888	1,700,000	1 50	2,550,000
1889	2,112,166	1 48	3,126,005
1890	2,516,054	1 30	3,170,870
1891	2,753,722	1 31	3,607,375
1892*	3,007,276	1 31½	3,954,568
1893	2,881,931	1 37½	3,960,331
1894	3,611,214	1 35⅝	4,899,774
1895	3,190,843	1 12½	3,590,141
1896	3,191,748	1 01⅛	3,227,357
1897	3,291,806	1 07	3,488,380
1898	3,860,405	1 08½	4,193,159
Totals	40,527,306	....	$50,585,640
Output previous to 1880	3,000,000	$1 50	4,500,000
Grand totals	43,527,306	....	$55,085,640

*Figures for 1880 to 1884, inclusive, and for 1892 taken from United States Geological Survey reports. All others taken from reports of State Inspector of Coal Mines.

we consider that of all the coal going over the screens from forty-five to forty-seven per cent. passes through, and must be sold either as slack or as nut coal, it is readily seen that a total average of $1.05 is fully as high as could be expected when the lump-coal rate is $1.35. Different mines with different classes of miners obtain slightly different ratios, but in general it may be estimated that for every hundred tons of coal taken from the mine about fifty-five tons of lump coal, fifteen tons of nut coal and thirty tons of slack coal are obtained.

In other parts of the state where coal is mined either by stripping or by the long-wall process the proportion of slack and nut coal is greatly reduced. In fact, where coal is loaded directly on the cars for shipment mines operated by the long-wall process rarely screen their coal at all, as there is practically no fine coal produced by the mine operations. This same coal, however, when kept in bins for some weeks or

months, slacks to a varying degree and the retailer therefore is quite frequently compelled to screen it, in which case he has the lesser grades of coal to supply to his customers.

It is difficult to make a prediction of the value or amount of the output for 1899. During the first third of the year the output was in excess of the corresponding time for 1898. Shortly after this the coal miners' strike developed, the magnitude of the effects of which is entirely unknown at present. Matters may be adjusted within a few weeks or months so that no serious results will follow. On the other hand it is entirely possible that the scenes of 1893 will be repeated with their baneful effects.

IV.—OIL AND GAS.

THE oil and gas industry during 1898 was fairly active. The oil production was confined to the vicinity of Neodesha and practically all the output of the state was sent to the Neodesha refinery, which produced 88,000 barrels of refined oil, worth, about $2 a barrel. There are few if any private wells in operation in the state. Oil is used to a limited extent by the gas factories in the various cities where the water-gas plants are in operation. It frequently happens that the oil such gas companies use in the manufacture of gas comes from outside the state, rather than from our Kansas fields. This is an illustration of one of the peculiar phases of the oil business which it is difficult for an ordinary person to understand. Table XIII shows the output for 1898 and also the total output for the past ten years.

TABLE XIII.

PRODUCTION OF PETROLEUM IN KANSAS FROM 1889 TO 1898, INCLUSIVE.

Figures from 1889 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

Year.*	Barrels.	Year.	Barrels.	Price per barrel.	Value.
1889......	500	1894......	40,000	48 cts.	$19,200 00
1890......	1,200	1895......	44,430	64 "	28,435 20
1891......	1,400	1896......	113,571	63 "	71,549 73
1892......	....	1897......	90,000	60 "	54,000 00
1893......	18,000	1898......	†88,000	$2 00	176,000 00
		Totals..	397,101	....	$358,504 93

*Totals include estimated value, $9,320, of the product from 1889 to 1893, which was 21,100 barrels.

†Refined oil.

GAS.

The gas production during the year was the largest ever known, reaching over $188,000 in value. This increase is due largely to the extensive use of gas in zinc smelters. The Robert Lanyon's Sons Company had a large smelter in operation during the entire year at Iola, and, but for a disastrous fire, would have operated 2400 retorts throughout that period, Their large plant at La Harpe, which is to

contain 3000 retorts when completed, began operations in December, 1898, so that no account is taken of the gas consumed at that plant in the statistics for this year. The W. & J. Lanyon Company operated an 1800-retort plant at Iola continuously throughout the year. The Nicholson Smelting Company did not get their plant started until well on into 1899; neither did the Edgar Zinc Company, at Cherryvale. Therefore, there were but two smelters using gas during the year; but, beginning with 1899, the gas consumed in gas furnaces will be much more than doubled.

The brick industry in the gas fields for 1898 was slightly greater than in 1897, representing a correspondingly larger consumption of gas. The Iola Brick Company and the Coffeyville Brick Company were the two principal ones. A smaller plant was started at Cherryvale, but was operated only a short time, so that its output is not included in our statistics of the brick output, and therefore its consumption of gas is also neglected. It is understood the Coffeyville Brick Company will establish a brick plant at Cherryvale and conduct an extensive business during 1899. The plant, however, was not quite completed at the close of 1898.

The consumption of gas for domestic uses by various cities in the gas belt does not differ materially from that of the preceding year, excepting in a few cases where gas is newly piped. This is particularly true at Chanute, a city into which the gas pipes were laid late in 1897. The domestic consumption during 1898 was large—in fact, almost as large as that of any other city of the state, exceeding $15,-000. The following table gives an approximation of the gas used in various places for all purposes:

TABLE XIV.

SHOWING VALUE OF THE NATURAL GAS CONSUMED DURING 1898 IN EACH OF THE GAS FIELDS OF KANSAS.

Locality.	Value of product.	Locality.	Value of product.
Iola	$79,600	Osawatomie	$9,500
Coffeyville	30,000	Neodesha	7,400
Cherryvale	15,695	Parsons	2,500
Chanute	15,051	Wyandotte	500
Independence	15,000	Chetopa*	100
Paola	13,500	Total	$188,846

*Production at Chetopa was during December only.

TABLE XV.

VALUE OF NATURAL GAS PRODUCED IN KANSAS FROM 1889 TO 1898.

Figures for 1889 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.	Value.	YEAR.	Value.
1889	$15,873	1895	$112,400
1890	12,000	1896	124,750
1891	5,500	1897	155,500
1892	40,795	1898	188,840
1893	50,000		
1894	86,600	Total	$792,264

GEOLOGY OF THE OIL AND GAS FIELDS.

Thus far in our studies of the geology of Kansas almost nothing has been published regarding the geology of the oil and gas of the state. A few scattering papers by different geologists have appeared from time to time in the last ten years or more, but no systematic exposition of the general conditions has been published. The neglect of this department along this line is due principally to the fact that a special report is contemplated on the subject in the near future, for which a great deal of material has already been gathered. As it is somewhat uncertain when this report will be issued, a brief outline of the geology of the Kansas oil and gas fields will be included here.

The general stratigraphy of eastern Kansas has been quite thoroughly studied and represented in the first part of Volume III, University Geological Survey Reports, from which report a few illustrations are here reproduced.

The Coal Measures of Kansas, which are the oil and gas producing formations, are exposed over approximately 20,000 square miles in the eastern end of the state. At the base of the Coal Measures lies the Subcarboniferous, or Mississippian, exposed in the extreme southeastern corner of Cherokee county over an area of from thirty to thirty-five square miles. The upper surface of the Mississippian limestone dips to the west along the south line of the state a little more than twenty feet to the mile, to as far west as Cherryvale, the westernmost point at which it has been reached by the drill. In a northwesterly direction the dip is considerably less, averaging from six to ten feet to the mile, depending upon the direction. North of the state line the inclination of the surface of the Mississippian seems to be less. A deep well was drilled last autumn at Madison, in

the north part of Greenwood county, which was carried to the depth of 1896½ feet, reaching what was supposed to be the Mississippian limestone, but about which there may be some doubt. Other wells east of this point show that the general dip of the strata from Fort Scott westward to Emporia is not as great as that along the south line of the state. Still farther north the general inclination to the west and northwest is greater than in this middle territory.

Cherokee Shales.

At the base of the Coal Measures lies a heavy bed of shales, the Cherokee shales, in which may be found a great deal of sandstone quite irregularly distributed. The Cherokee shales are exceedingly rich in organic matter, carrying the Weir-Pittsburg coal, the Fort Scott coal, the Leavenworth coal, the principal part of the coal mined in Labette county, and doubtless a great deal of other coal yet undiscovered. The greater part of these shales are black, some of them being exceedingly bituminous. The sandstone in the Cherokee shales is variable in quality as well as location, but generally it is moderately coarse, furnishing a good reservoir for oil, gas, and water.

These Cherokee shales are known to extend northeast almost the entire width of the state, and probably do extend entirely across it and to a considerable distance beyond, both north and south. Their westward extension, as shown in Plates I and II (reproduced from Volume III, University Geological Survey of Kansas), is known to reach as far as Madison. The deep well at Madison above referred to passed through 293 feet of them before striking the hard rock supposed to be the Mississippian. Other deep wells in many parts of the state show conclusively that this heavy shale bed reaches far to the west, such as the wells at Topeka and McFarland, each of which was carried into the Cherokee shales some distance, but neither of which entirely passed through them. The evidence of the wells which did go through them shows that in their westward extension they gradually become thinner. How far west they actually go is entirely conjecture. Should the rate of diminishing thickness be maintained as exhibited from their outcroppings to Madison they will extend to the middle of the state or beyond.

Our knowledge of the general character of the sandstones in the Cherokee shales is obtained by a study of the sandstone outcroppings in the eastern part of the state, and from the records of the many deep wells that are drilled in the oil and gas region. It is known that

a sandstone bed is not continuous over a very wide area, but that any particular sandstone found in a given place may entirely change into shale in any direction within a few miles. Broadly speaking, therefore, the sandstones are lenticular deposits which apparently have no direct connection with each other, although they may be never so closely related in character and in the particular position in the shale beds which they occupy.

This phase of the subject is a most important one in the practical development of the oil and gas fields. It makes prospecting much more uncertain, but at the same time renders it less possible for the well or set of wells to entirely exhaust a given area. If a well at Iola draws its gas from a certain sandstone horizon, the limited extent horizontally of this sandstone will necessarily limit the area over which the wells in question will be able to exhaust the supply of gas. If the particular sandstone beds of Iola do not extend to Cherryvale or Neodesha or Benedict, it is practically certain that there can be no direct relation between the gas of any two of the areas named.

The Cherokee shales, or rather the sandstones within the Cherokee shales, furnish the gas at Chetopa, Coffeyville, Cherryvale, Neodesha, Benedict, Erie, Iola, and La Harpe, and all other points in that part of the state.

Formations above the Cherokee Shales.

Above the Cherokee shales there is a succession of alternate beds of limestones and shales throughout the whole of the Coal Measure area, as illustrated in Plates I and II. Each shale bed has a considerable amount of sandstone within it, arranged practically the same as that already described for the Cherokee shales. Many such sandstones have been oil or gas producers, and in some parts of the state, notably, Osawatomie, Paola, and Ottawa, all the gas obtained has come from some of these higher sandstones.

There is no essential difference yet known in the general relations between the sandstones and the shales of these upper horizons and the sandstones and shales below. When a well is started at any point far enough west to cause it to penetrate any of these limestones it passes through successive horizons of limestone and shale. In general, the further north and west a well is located the more likely it will be to obtain gas from some of the upper horizons, and the more liable the sandstones within Cherokee shales are to be filled with salt water. By an examination of Plate III, a map showing the out-

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croppings of the more important limestones of the state, likewise reproduced from Volume III, one can readily determine the relative stratigraphic position of any point in the gas fields. If a well were started at Eureka one might expect to pass through the shale beds lying between the Oread and Burlingame limestones, and all of the succeeding formations below. If a well were started at Fredonia the first limestone reached would be the Iola. If one were started at Ottawa, in the valley of the Marais de Cygnes river, the first limestone reached would be the Garnett, unless perchance the mouth of the well happened to be below this particular horizon.

Depth at which Gas is Found.

The depth at which gas is generally found in Kansas ranges from 500 to 1000 feet, although some wells are known beyond each of these extremes. It is readily apparent why gas must come from a considerable depth. If it is maintained at a pressure of 350 pounds to the square inch, sufficient covering of rock strata must be over it to prevent its escape — a tendency that is very strong with so high a pressure. The superimposed strata must be sufficient in amount to have a weight greater than the gas pressure exerted on it; and it must be sufficiently impervious to prevent the leak which would occur were the strata very porous. Fine-grained clay shale is the best material known for holding gas down, on account of the closeness of grain, thereby causing all openings to be filled with the fine-grained clay particles. Were the cover rock of a porous nature, such as sandstone, or of a hard, firm nature, such as limestone or flint, readily rendered porous by fracture, the thickness of the covering would necessarily have to be much greater.

It is an interesting fact that in all gas fields, with few if any exceptions, the overlying formations, whatever they may be, include one or more beds of fine-grained compact shales. Thus the Trenton limestone, which is the gas and oil producer of Indiana and western Ohio, is immediately overlaid by the fine-grained Utica shales, which in turn are held down by the heavy beds of the Hudson River and Niagara limestones. In eastern Ohio and Pennsylvania, likewise, wherever gas is found in any considerable quantity, a heavy bed of fine-grained shale overlies the gas-producing formations, serving as an impervious covering to prevent the gas from leaking.

On the other hand, gas rarely is found at a very great depth. But few places have yet been discovered where gas could be obtained in

any considerable quantity at a depth greater than 1500 feet. The reason for this is likewise apparent. As water is heaver than gas or oil, and as there is a constant supply of surface-water, which falls as rain-water and penetrates to great depths, there is a tendency to fill all the underground cavities with this water. The gas can occupy the open spaces in the rock only when it has a sufficiently strong pressure to prevent water from driving it out. This tendency of the water to replace the gas is probably entirely dependent upon the depth, while the capacity of gas to resist the encroachments of water is principally dependent upon the pressure under which the gas exists; therefore, the deeper the well the greater the gas pressure when gas is found, and likewise the stronger the probability of water being found instead of gas.

The accidental condition of the water being salt or otherwise probably has no bearing upon the question of gas supply. It is generally true that deeply buried water is more or less mineralized in proporation to the opportunity for drainage afforded the water-bearing horison. If a porous stratum comes to the surface in two or more places differing in altitude, so that the higher exposure may act as a gathering area for the rain-water, the lower outcropping usually is notable as an area of springs. The constant passage of water from the higher to the lower has long ago washed the soluble saline ingredients out of the rock masses, and therefore this particular horizon will produce fresh water wherever reached at intermediate points, no matter how far below the surface the water may chance to be. This is well illustrated by the great Dakota sandstone formation of the great plains area. This sandstone comes to the surface along the eastern foothills of the Rocky Mountains and again appears at the surface throughout central Kansas, Nebraska and the Dakotas at an elevation of from 3000 to 4000 feet below the western exposures. The rain-water falling near the mountains gradually works its way through sandstone beds, although at intermediate areas they lie in places more than 2000 feet beneath the surface. Wells drilled into this sandstone generally supply fresh water.

But where the strata dip in one direction and the surface of the earth dips in the opposite direction, as in the case for eastern Kansas as shown in Plates I and II, we have a porous horizon gathering rain-water with no outlet. Such horizons when penetrated further westward produce water highly charged with salt and other soluble materials held by the formations through which the water has passed.

The prospecting wells, therefore, when finding water as much as 600 or 1000 feet below the surface, generally find the same to be salt water for the reasons given. That, perhaps, is all the essential relations between salt water and gas.

Area within which Gas may be Looked For.

From the foregoing discussions it is readily seen that Cherokee county and the southeastern part of Crawford county failed to yield a supply of gas on account of the absence of a sufficient mantle to protect the gas from escaping. Here the Cherokee shales, the great gas-producing horizon, come to the surface. That these shales in this particular place do contain some gas is abundantly proved by the history of well digging and drilling throughout the area considered. A well driller of wide experience, one who has drilled hundreds of holes prospecting for coal in this particular territory, reported to the writer that fully one-third of all the wells drilled produced a little gas. Could a gas-tight mantle be spread over that part of the state, even now, to remain sufficiently long, it is quite possible gas would accumulate beneath it, producing a great gas area.

Passing westward from the area named beyond the outcroppings of the Oswego and Pawnee limestones, as shown on Plate III, a mantle of from 200 to 500 feet in thickness is supplied, with a correspondingly large amount of gas, as is shown by the Chetopa and Oswego wells, which have a light pressure; those farther west around Mound Valley, with a heavier pressure, and finally those beyond the Erie limestone, where the strong wells of Cherryvale, Independence, Coffeyville, Neodesha and Benedict are obtained. Passing still farther westward until one has gone beyond the outcroppings of the Iola limestone the mantle is correspondingly heavier, the gas leaks less, and the pressure at which the gas may be held is greater.

As we pass westward, likewise, the essential conditions for retaining the gas in some of the upper shale-bed horizons become greater. This is doubtless an important factor in the production of gas by the overlying shale beds, as witnessed at Paola, Osawatomie, Ottawa, and some of the points near the state line between Paola and Kansas City.

The further consideration of this same series of conditions will show that by continuing still further west beyond the eastern limits of the Burlingame limestone and into the Flint Hills region one need hardly expect to find a flow of gas from the Cherokee shales, even should the shales be found, simply because the Cherokee shales

throughout the area indicated lie so deeply buried that the porous sandstone beds are entirely filled with water. Whether or not the overlying shale beds which pass to the westward as shown in Plates I and II, are gas bearing can only be determined by prospecting.

This department is frequently called upon to give advice regarding the advisability of prospecting for gas in the Flint Hills area, or further to the west. A number of different cities have contemplated putting in prospecting wells, with a view to municipal ownership of the wells. Private individuals have considered similar enterprises and have asked for an opinion on the advisability of the matter. We have constantly advised that the probability of failure was greater than that of success for all points west of the outcroppings of the Burlingame limestone, as shown in Plate III. The reasons for such advice have already been given, namely: That the Cherokee shales, the greatest oil- and gas-producing horizon in the state, here lie so deep that probably water has entirely driven out both the oil and the gas, provided either was present; and second, that the overlying shale beds, wherever they have been explored, have produced so small quantities that the risk of finding gas in those is correspondingly greater. Therefore there is a constantly decreasing degree of probability for the finding of either oil or gas as one moves westward.

But within the area of the state bounded on the west by the outcroppings of the Burlingame limestone and on the east of the Oswego limestone gas may reasonably be expected. But developments thus far made show how uncertain the results of prospecting, yet each year opens up new fields and adds thereby a degree of probability to any part of the territory unexplored becoming productive when sufficiently developed.

V.—GYPSUM.

THE various gypsum industries during 1898 were only moderately prosperous. The mills producing plaster of Paris and gypsum cement plaster from rock gypsum operated about as usual. Of those making plaster from the gypsum earth material, the Salina Cement Plaster Company and the Dillon Cement Plaster Company were the two most prominent. The Acme Cement Plaster Company, having closed its business at Rhodes, did no business in the state. The American Cement Plaster Company, with mills at Mulvane now in active operation, had not their plant completed until about the beginning of 1899, and hence had no output during 1898. The general tendency of the market throughout the year was downwards, although probably the aggregate of plaster used in building purposes was as great or greater than that of the preceding year. Early in January, 1899, the mills at Sun City, in northwestern Barber county, began operations, after a period of several years' idleness.

The output for 1898 has been encouraging. The general increase in building operations throughout the Mississippi valley has produced a corresponding increase for the different brands of hard plaster. This has resulted in great activity on the part of all companies interested in the plaster business. The Salina Cement Plaster Company at present is the largest producer in the state, with the American Cement Plaster Company a close second. The Best Brothers Company (Limited), of Medicine Lodge, is hardly to be compared with the other companies, as they make a different grade of plaster, formerly known in the market as the Keene cement plaster, which is very superior to the ordinary brand, and which also brings a correspondingly higher price.

It is an admitted fact that the gypsum earth deposits in the state are becoming somewhat scarce, and unless new discoveries are made it will be but a short time until the supply is exhausted. The principal new deposits recently discovered are the one at Sun City and that on the farm of Mr. Snyder, of Mulvane. The heavy de-

posits in Texas and possibly in Oklahoma territory and Indian territory are attracting manufactories, which are supplying a correspondingly increasing proportion of the plaster made from this class of material. The rock gypsum deposits in the state, however, are as yet almost untouched and can furnish enough material to supply America with plaster for hundreds of years. The following table shows the output and value of Kansas mills from 1889 to 1898, inclusive:

TABLE XVI.

SHOWING AMOUNT AND VALUE OF GYPSUM PRODUCED IN KANSAS FROM 1889 TO 1898.*

YEAR.	Output in tons (2000 pounds).	Average price per ton.	Value of output.
1889	17,332	$5 44	$94,235
1890	20,250	3 58	72,457
1891	40,217	4 01	161,322
1892	41,016	4 76	195,197
1893	43,631	4 16	181,599
1894	64,889	4 65	301,884
1895	72,947	3 74	272,531
1896	49,435	3 00	148,371
1897	50,045	5 05	252,811
1898	39,776	3 26	129,652
Totals	439,538	....	$1,810,059

* Figures from 1889 to 1896, inclusive, are taken from the reports of the United States Geological Survey.

VI.—BUILDING STONE.

DURING 1898 the stone industry of Kansas was about on a par with other industries, compared with like industries for 1897. It has been impossible to gather accurate data regarding the total product for 1898. This is partly due to slight negligence on the part of some operators in failing to respond to letters of inquiry sent them, but is principally due to our inability to obtain a perfect quarrymen's directory. There are so many small stone quarries in the state that do a slight business, sometimes suspending entirely for a year or more at a time and again renewing operations, that it is exceedingly difficult to come in touch with nearly all of them. These small items in the aggregate constitute a very considerable proportion of the total stone industry.

The same general statement may be made regarding the sand industry and the lime industry. Sand is dredged from the Kansas river bed in great quantities at many places from Kansas City to Manhattan or beyond. In addition to this it is obtained in lesser quantities in many other places away from the Kansas river, particularly for local consumption.

Unfortunately we have no very good lime-producing limestone within our limits, and therefore the various lime producers generally produce a somewhat inferior grade of lime. That this is abundant is shown from the general market conditions. The lime dealers in almost every town in the state import large quantities of lime.

The following tables of chemical and physical tests are reprinted from the report for 1897, pp. 77 to 79 inclusive:

TABLE XVII.—TESTS AND ANALYSES OF KANSAS BUILDING STONES. LIMESTONE.

COUNTIES.	FORMATIONS.	Crushing strength.........	Weight per cubic foot............	Specific gravity...	Ratio of absorption.....	Analyses.						Remarks.
						Insoluble matter....	Oxides of iron and alumina...	Calcium carbonate.	Magnesium carbonate.	Sulphates...	Moisture....	
		Lbs.	Lbs.			%	%	%	%	%	%	
Franklin.....	....	19,279	165.4	2.65	.01	8 00	1.35	90.00	.12	.02	....	From Ottawa; average from three blocks.
Allen........	....	....	......	......	......	1.53	1.75	94.12	2.72	....	....	From Humboldt.
Leavenworth,	....	7,862	168.5	2.70	.02	5.91	2.47	89.88	1.11	.38	....	From Lansing; average from five blocks.
Leavenworth,	....	15,961	169.1	2.71	.004	6.20	3.31	88.17	1.88	.28	.04	From Lansing.
Cowley......	Permian............	....	165.4	2.65	.045	13.60	2.55	76.16	7.63	....	....	From Arkansas City; fine grained and homogeneous; no appearance of fossils.
Cowley......	Permian............	4,555	157.3	2.52	.07	4.25	.85	94.06	.62	....	....	From Winfield.
Marion......	"	....	167.0	2.67	.07	5.13	3.15	53.16	38.33	....	....	From Marion; this stone appears to have nearly the composition of dolomite; it is fine grained, takes a smooth surface, and is grey in color.
Marion......	Carboniferous......	5,824	169.8	2.72	.01	6.85	1.91	59.21	30.09	.95	.90	From Marion.
"	Permian............	8,136	167.6	2.68	.05	13.51	1.65	61.64	22.72	....	....	From Marion; produced by I. Kuhn & Co.; dark grey; not perfectly homogeneous, occasional spots.
Marion.......	Permian............	13,711	170.7	2.73	.04	6.75	1.59	51.05	40.51	....	....	Produced by I. Kuhn & Co.; average from four blocks; five miles northeast of Marion.
Marion.......	Permian............	12,364	168.2	2.69	.03	5.51	1.24	91.50	1.62	....	....	
Clay.........	"	10,291	170.4	2.73	.05	9.50	6.40	60.04	24.72	....	....	From Clay Center; average from three blocks.
Butler.......	Permian............	2,727	162.9	2.61	.01	5.04	.96	93.32	1.06	....	....	From El Dorado.
Douglas......	Carboniferous......	11,630	167.6	2.68	.007	3.53	1.07	94.18	1.16	....	....	Crushing strength is the average from five blocks; from Lawrence.
Franklin.....	....	2,940	162.0	2.59	.03	1.18	3.09	92.71	2.64	....	....	From Greeley.
Leavenworth,	....	8,223	170.4	2.73	.01	12.97	3.06	78.46	1.16	2.32	....	From Lansing.
Marshall.....	....	4,216	158.8	2.54	.06	13.89	4.29	80.10	1.00	.39	....	From Beattie; average from five blocks.

TABLE XVII—Continued.—TESTS AND ANALYSES OF KANSAS BUILDING STONES. LIMESTONE.

Counties.	Formations.	Crushing strength	Weight per cubic foot	Specific gravity	Ratio of absorption	Analyses. Insoluble matter	Oxides of iron and alumina	Calcium carbonate	Magnesium carbonate	Sulphates	Moisture	Remarks.
		Lbs.	Lbs.			%	%	%	%	%	%	
Marshall		9,810	163.2	2.61	.03	8.75	2.37	84.80	2.80	.78	.25	From Beattie; average from five blocks.
Marshall	Carboniferous	6,543	163.5	2.62	.05	14.01	1.34	80.31	3.87	....	....	From Beattie; average from four blocks.
Riley	Permian	3,272	159.1	2.55	.07	....	....	....	....	....	....	From Manhattan; quarried by Ulrich Bros.
Wabaunsee		....	166.3	2.67	.01	6.22	1.74	89.68	1.99	....	....	From Alma.
"	Carboniferous	7,646	161.3	2.58	.05	9.12	.70	88.55	1.25	....	....	From Alma; quarried by A. Zechser.
"		2,891	154.4	2.49	.06	10.37	2.49	84.53	2.35	....	....	Crushing strength is the average from five blocks.
Chase	Carboniferous	7,907	162.9	2.61	.04	7.30	1.05	90.00	1.60	.03	....	From Strong City; average from six blocks.
Chase		6,800	161.6	2.59	.04	8.57	3.62	84.72	1.75	.90	....	From Cottonwood Falls; quarried by Rettiger Bros.; crushing strength, average from four blocks.
Cowley		12,567	164.5	2.63	.01	3.34	1.69	93.98	.94	....	....	From Cambridge; quarried by H. Heddeman; average from five blocks.
Cowley	Carboniferous	3,649	153.5	2.46	.08	....	....	....	....	....	....	From Cambridge; average from five blocks.
Lincoln	Benton Cretaceous	......	......	......	......	....	....	....	....	....	....	No data; known as Lincoln marble, but is hardly a marble, not being sufficiently crystalline.
Hodgeman		......	......	......	......	5.06	2.08	91.30	.87	b...	.44	From Jetmore.
Hamilton	Benton Cretaceous	......	......	......	......	4.81	3.07	90.63	.84	b...	.08	From Coolidge.
Norton	Loup Fork Tertiary	4,277	156.3	2.51	.06	8.29	a .90	89.00	2.00	....	....	From Norton; crushing strength, average from four blocks.
Cherokee	Subcarboniferous	9,520	166.0	2.66	.003	8.00	.69	97.32	.80	....	....	From Galena.
Allen		....	167.3	2.68	.02	2.75	5.91	91.02	.14	....	....	Iola Marble Company.
"		7,683	166.0	2.66	.02	2.63	1.76	94.10	1.54	....	....	Av. crushing strength—five blocks.

Montgomery..		7,731	169.8	2.72	.006	16.15	1.91	79.25	1.80	....	....	From Independence.
Barber		10,349	163.5	2.62	.01	1.85	1.95	94.62	1.40	....	....	Average from six blocks.
Franklin		12,809	167.3	2.68	.008	1.18	2.38	94.77	1.07	....	....	From Lane; quarried by Hanway.
"		14,415 } 16,609 }	169.8	2.72	.005	3.82	a .77	94.21	1.30	....	....	" " " "
"		10,469	167.9	2.69	.009	3.94	1.20	93.61	1.20	....	....	" " " "
"		12,354	167.9	2.69	.006	4.79	1.18	93.30	1.26	....	....	" " " "
Anderson	Carboniferous	14,647	168.2	2.69	.004	4.30	.81	92.76	.95	.23	.43	From Garnett.
"		4,399	154.2	2.47	.04	.61	a1.51	97.32	.32	.43	....	" "
Jackson		11,005	163.5	2.62	.02	10.93	2.02	83.99	2.66	.14	....	Quarried by A. W. Charles.
Woodson		14,145	168.2	2.69	.007	6.80	2.60	88.03	2.04	.21	....	From Yates Center.
Elk		10,162	166.2	2.66	.008	.66	2.13	93.49	3.04	.36	....	From Moline.
Leavenworth,		5,515	160.4	2.57	.02	17.49	4.09	69.07	3.06	.37	....	From Soldiers' Home.
Wabaunsee		5,273	156.3	2.50	.06	3.27	2.61	92.50	1.62	....	....	From McFarland; average from five blocks.
Miami		2,036	128.2	2.50	.06	1.50	.95	96.50	.74	....	....	From Fontana.
"		13,802	165.4	2.65	.004	1.35	1.32	96.09	1.00	....	....	From Fontana; crushing strength, average from four blocks.
Miami		4,625	145.4	2.33	.04	2.44	.82	95.57	.80	....	....	From Fontana; crushing strength average from five blocks.
Jefferson		8,767	169.8	2.72	.005	6.98	1.04	90.01	1.66	....	....	From Winchester.
Nemaha		6,757	161.6	2.59	.05	11.97	3.59	81.98	1.20	.55	.29	From Sabetha.
Leavenworth,		12,266	161.1	2.71	.01	......	......	......	......	....	....	From Lansing; crushing strength, average from five blocks.
Brown		4,721	164.5	2.63	.06	11.83	5.53	81.91	1.56	.05	....	From Horton; owners, Frey Bros.; crushing strength, average from five blocks.
Douglas		10,339	166.6	2.67	.01	2.29	1.79	95.02	.79	....	....	From Lawrence; crushing strength average from five blocks.
Douglas		11,038	166.6	2.67	.01	8.02	2.05	88.54	1.29	....	....	From Lawrence.
Allen		17,160	168.8	2.70	.008	1.99	1.21	95.20	1.10	....	....	From Humboldt; crushing strength, average from three blocks.
Allen		11,267	166.0	2.66	.02	3.79	1.07	93.20	1.01	.20	....	From Humboldt; crushing strength, average from five blocks.

a In ferrous state. b Not determined.

All of these limestones are fossiliferous in appearance. The surface appears to polish very well. Fossil outlines are very distinct in most of them. The prevailing color of the samples is a sort of gray, occasionally brownish. The polished surface of certain bluish-gray specimens is quite dark. The polish of some of these stones is very good indeed.

The above table is from the Sixteenth Annual Report of the U. S. Geological Survey.

The actual commercial importance of the Kansas stone quarries for 1898 is shown in the appended statistical tables, in which is given the total output of the Kansas quarries for 1898 and preceding years.

It is impossible to estimate the total value of stone quarried in Kansas; so many thousands of cords have been taken out a little at a time by the individual farmers and by the local dealers to be used in the foundations of buildings and the construction of bridges and in many other ways, that nothing but the merest guess could be applied to them. It is well within the limits of probability, however, to say that more than five million dollars' worth of stone have thus been produced.

The future prospect of our quarries is dependent almost entirely upon the extent of internal improvements in Kansas and adjacent territory. The largest proportion of stone will come from the Cottonwood Falls series of limestone, as they furnish such excellent dimension stone. Should a demand be created, the quarries already in operation and others which would soon be put in operation would readily supply many times the amount they thus far have produced.

TABLE XVIII.

SHOWING VALUE OF BUILDING STONE PRODUCED IN KANSAS FROM 1888 TO 1898.

Figures for 1880 to 1896, inclusive, are taken from the reports of the United States Geological Survey.

YEAR.	Sandstone.	Limestone.
1880	$11,000	$131,570
1888 *	1,000	144,000
1889	149,289	478,822
1890	149,289	478,822
1891	80,000	300,000
1892	70,000	310,000
1893	24,761	175,173
1894	30,265	241,039
1895	93,394	316,688
1896	18,804	158,112
1897	23,180	173,000
1898	25,000	180,000
Totals	$675,972	$3,087,226

* Reports for 1888 include only (for sandstone) the production from Ritchie; and (for limestone) the production from Winfield, Florence, Augusta, and Oketo.

VII.—CLAYS.

THE Kansas clay industries during 1898 were very prosperous, the output being much heavier than ever before known. The increase was confined principally to vitrified brick for street paving, but other styles of brick likewise were in good demand, and a few of the factories, notably the Pittsburg, Coffeyville and Columbus factories, did a good business in manufacturing drain tile. Ornamental earthenware is manufactured to a limited extent at a few of the yards.

The quality of the Kansas clays is most favorable for the manufacture of all kind of brick excepting fire-brick. A great variety in color may be obtained frequently from clays in the same vicinity but occupying slightly different positions. In general the different grades of red brick are most easily made and likewise are in great demand.

With the general increase of prosperity throughout the state, street paving with brick began in many cities. It is probable that this industry will be continued for years to come and that the manufacture of vitrified brick for paving purposes will rapidly increase in importance. As it now is, over twenty-six million vitrified brick were manufactured in Kansas during the year, at an average value at the kiln of $7.28, aggregating more than $190,000. The next largest production was of common brick, which amounted to over twenty-three millions in number, with an average value at the kiln of $5.25 per thousand, aggregating over $121,000 in value. A number of new plants are being erected, and old plants now in operation report that the demand for brick is almost unequaled in the history of the state, particularly for vitrified brick for street-paving purposes.

The clay used in nearly all brick making is either Coal Measure clay shales or the glacial loess clay so abundant over the northeastern part of the state. The following tables, XIX and XX, show an itemized statement of the amount and value of different grades of clay goods made during 1898 and also a summary of the total clay products for the state since 1892.

TABLE XIX.

SHOWING AMOUNT, KIND AND VALUE OF KANSAS CLAY PRODUCTS IN 1898.

Number of firms reporting, 26.

DESCRIPTION.	Quantity, in thousands.	Average price per thousand.	Value.
Common brick........	23,157	$5.250	$121,574 25
Dry-pressed brick......	5,050	6.330	31,966 50
Re-pressed brick.......	1,525	7.000	10,675 00
Vitrified brick.........	26,182	7.281	190,735 00
Face brick	611	8.000	4,888 00
Fire-brick.............	120	10.000	1,200 00
Drain-tile	544	15.794	8,592 00
Flower-pots	50	3.000	150 00
Total thousand brick,	56,645	....	....
Total value..........	....	....	$390,630 00

TABLE XX.

SHOWING AMOUNT, KIND AND VALUE OF KANSAS CLAY PRODUCTS FROM 1892 TO 1898.

Figures for 1893 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.	Common brick.			Dry-pressed brick. *a*			Re-pressed brick.			Vitrified brick.			Other brick.			Drain-tile, value.	Other clay products, value.	Total value.
	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.			
1892 *b*....	25,000	$5 75	$142,750	550	$7 50	$4,125	....	....	....	10,600	$8 00	$81,800	....	....	....	$6,000	$5,000	$242,675
1893 *c*....	20,000	5 75	115,000	1,000	7 50	7,500	....	....	....	8,000	8 00	64,000	....	....	....	5,000	4,500	196,000
1894 *d*....	24,518	5 75	141,042	....	....	....	....	....	....	7,948	7 21	57,310	....	....	....	8,048	12,175	218,575
1895......	20,756	5 87	121,892	3,730	6 91	25,775	....	....	....	7,902	7 87	62,190	....	....	....	4,090	33,700	247,647
1896......	19,694	5 59	110,254	1,541	6 13	9,440	....	....	....	16,934	7 39	125,293	....	....	....	4,400	10,700	260,087
1897......	19,548	5 33	104,257	1,948	5 26	10,241	....	....	....	18,378	7 18	132,222	....	....	....	7,600	11,000	265,320
1898......	23,157	6 34	146,765	5,050	5 55	28,050	1,525	$6 72	$10,250	26,182	7 28	190,735	731	$8 33	$6,088	8,592	150	390,630
Totals,	152,673	....	$881,960	13,819	....	$85,131	1,525	....	$10,250	95,944	....	$726,550	731	....	$6,088	$43,730	$77,225	$1,620,934

a. Previous to 1898 all pressed brick were figured together.
b. Only a partial report is obtainable for 1892.
c. Estimated.
d. For 1894 the common and pressed brick were figured together.

VIII.—HYDRAULIC CEMENT.

THE conditions of the hydraulic cement industry in Kansas during the year 1898 were practically unchanged from 1897. Fort Scott is the only place in the state where this cement is made at present. Here the two mills, the Fort Scott Hydraulic Cement Company and the C. A. Brockett Cement Company were in active operation throughout the year and produced an output about the same as that for 1897, or 160,000 barrels. The price of this hydraulic cement ruled a little lower than for the previous year, being reported by the manufacturers as averaging thirty-eight cents per barrel, as against forty cents in 1897.

The material from which the hydraulic cement is made is an impure Coal Measure limestone. In our report on the Mineral Resources of Kansas for 1897, page 67, there is a list of twelve analyses of Fort Scott rock, with a number of others inserted for comparison. As a matter of convenience for reference tables XXI and XXII are reprinted here.

It is probable that a good grade of hydraulic cement could be made from many other limestones found at different places in the state. Some of the limestones in Greenwood, Butler, Elk and Chautauqua counties are known to be good cement rocks, but no factory has yet been established to use them. Years ago a plant was in operation at Manhattan making an hydraulic cement from one of the Permian limestones. Should a market be developed for this grade of cement there are many places in the state from which suitable material could be gathered. Table XXIII shows amount and value of the total hydraulic cement production in this state from 1888 to 1898.

A factory is now in the course of construction at Iola for the manufacture of Portland cement from the Iola limestone and the shale near by. This plant when completed will have a capacity of 1000 barrels per day. Its operations will be watched with great interest; for should it be possible to make Portland cement from this limestone by the addition of clay shale, a vast field will be opened up which should be entered at once by other companies. There are many places in the

TABLE XXI.—ANALYSES OF CEMENT ROCK.

Cement rock from—	Calcium carbonate, $CaCO_3$	Magnesium carbonate, $MgCO_3$	Silica, SiO_2	Silica and insoluble	Ferric oxide, Fe_2O_3	Ferric oxide and alumina	Alumina, Al_2O_3	Potash and soda, K_2O, and Na_2O	Water, H_2O	Water and undetermined	Undetermined	Total	Analyst or authority.
Fort Scott cement rock No. 1*a*	73.95	2.26	18.75	....	2.32	....	2.15	....	0.37	....	0.20	100.00	Dr. E. Bartow.
" " No. 1*b*	63.05	12.21	16.64	....	4.43	....	3.09	....	0.26	....	0.32	100.00	
" " No. 1*c*	55.40	20.92	13.34	....	6.57	....	1.51	....	0.29	....	1.97	100.00	
" " No. 2*a*	60.21	17.30	15.48	....	2.98	....	2.71	....	0.31	....	1.01	100.00	
" " No. 2*b*	53.16	26.62	11.75	....	4.59	....	2.06	....	0.33	....	1.49	100.00	
" " No. 2*c*	51.12	15.88	24.25	....	5.04	....	2.28	....	0.63	....	0.80	100.00	
" " No. 3*a*	65.62	4.43	18.45	....	2.17	....	8.47	....	0.44	....	0.42	100.00	
" " No. 3*b*	64.93	11.01	16.27	....	3.87	....	2.91	....	....	....	1.01	100.00	
" " No. 3*c*	54.80	4.77	32.07	....	3.40	....	3.99	....	....	....	0.97	100.00	
" " No. 4	77.90	3.27	13.84	....	1.68	....	2.47	....	....	....	0.84	100.00	
" " No. 5	81.34	3.32	11.08	....	1.69	....	1.77	....	....	....	0.80	100.00	
Fort Scott, Kan.	65.21	10.65	....	15.21	....	....	4.56	....	....	....	4.37	100.00	Mineral Industry, vol. I.
Rosendale, Ulster county, N. Y.	45.91	26.14	....	15.37	....	11.38	....	....	....	1.20	....	100.00	
Utica, Ill.	42.25	31.98	....	21.12	....	1.12	....	....	1.07	....	2.46	100.00	
Milwaukee, Wis.	45.54	32.46	....	17 56	3.08	....	1.41	....	....	....	....	100.00	
Cement, Ga.	43.50	22.00	....	22.10	1.80	....	5.45	0.22	4.95	....	....	100.02	
Siegfried, Pa.	78 92	2.66	...	11.62	.	6.25	....	....	..	..	0.55	100.10	

Fort Scott cement rock No. 1 is from the quarries in southeast part of the city. No. 2 is from rock obtained northeast of Fort Scott. No. 3 is from rock at the cement works north of the city, the stratum tnere being about four feet thick. No. 4 is rock that is considered the best. No. 5 is a rock said to contain too much lime. *a* From top of stratum. *b* From middle of stratum. *c* From bottom of stratum.

The manufactured cement, as shown by different analyses, has the following composition:

TABLE XXII.—ANALYSES OF NATURAL HYDRAULIC CEMENT.

Hydraulic cement from—	Silica, SiO_2.	Alumina and iron oxide, $Al_2O_3+Fe_2O_3$.	Lime, CaO.	Magnesia, MgO.	Alkalis, Na_2O+K_2O.	Carbon dioxide, CO_2.	Sulphate of lime, $CaSO_4$.	Water, H_2O.	Undetermined.	Total.	Analyst or authority.
Rosendale, Ulster Co., N. Y.,	22.75	16.70	37.60	16.65	....	5.00	....	1.30	....	100	Mineral Industry, vol. I.
Utica, Ill.	35.43	9.92	33.67	20.98	....	....	....	....	....	100	
Akron, N. Y.	29.64	6.42	54.77	9.17	....	....	....	....	....	100	
Lehigh Valley, Pa	18.28	7.43	51.53	2.07	1.50	16.26	....	....	2.93	100	
Louisville, Ky	21.10	7 51	44.40	7.00	0.80	11.18	6.85	1.16	....	100	

TABLE XXIII.

SHOWING AMOUNT AND VALUE OF HYDRAULIC CEMENT PRODUCED IN KANSAS FROM 1888 TO 1898, INCLUSIVE.

The figures from 1888 to 1896, inclusive, are based upon the reports given by the U. S. Geological Survey.

YEAR.	Barrels.	Price per barrel.	Value of output.
1888	40,000	75 cts.	$30,000
1889	150,000	70 "	105,000
1890	150,000	70 "	105,000
1891	140,000	69 "	97,440
1892 *	110,000	69 "	77,000
1893	60,000	35 "	21,000
1894	50,000	50 "	25,000
1895	140,000	40 "	56,000
1896	125,567	40 "	50,226
1897	160,000	40 "	64,000
1898	160,000	38 "	60,800
Totals	1,285,567	....	$661,466

* Includes Kansas City, Mo.

eastern part of the state where limestones and shales of similar properties can be found in the greatest abundance. With a heavy importation of Portland cement from abroad a strong market for a good variety of the cement is assured.

IX.—SALT.

THE year 1898 was a prosperous one for the salt industry. The output reached a little over 1,800,000 barrels, which is about 400,000 barrels more than the product of 1892, the next most successful year. But the price ruled the lowest ever known, the average of the reports given by the various companies being twenty-seven cents per barrel, exclusive of cooperage. This brought a total value of less than half a million dollars, a sum that has been exceeded on four previous years. This is less than ten cents per hundred pounds, or two dollars per ton. It is difficult to understand how it is possible to manufacture salt at so low a rate. Table XXIV shows the output and value for 1898 and for the ten years preceding.

TABLE XXIV.

KANSAS SALT PRODUCTION:

Statistics for 1888 to 1896, inclusive, from United States Geological Survey reports.

YEAR.	Barrels.	Average price.	Value.
1888	155,000	$1.219	$189,000 00
1889	450,000	.45	202,500 00
1890	882,666	.45	397,199 00
1891	855,536	.357	304,775 00
1892	1,480,100	.523	773,989 00
1893	1,277,180	.369	471,543 00
1894	1,382,409	.383	529,392 00
1895	1,341,617	.36	483,701 00
1896	1,347,793	.31	519,475 00
1897	1,224,980	.34	417,626 94
1898*	1,810,809	.27	489,454 23
Totals	12,208,090	....	$4,778,655 17

* Cooperage in 1898 is reported at about twenty-five cents a barrel, and in other years at proportional rates, which should be added to above totals to give a correct idea of the magnitude of the salt industry.

In 1894 Mr. M. Z. Kirk, at that time a student of the University of Kansas, began a systematic examination of Kansas salt and the salt industry. After spending two seasons in the field he was obliged to

leave the University before his task was entirely completed.[1] The following paper by him embodies the more important results obtained. It is published here to serve as a preliminary report, and to supply the demand for information on the subject for a few years until a monographic report can be published.

KANSAS SALT.—By M. Z. Kirk.

History of Salt.

SALT as a chemical compound has been known but a few years. On account of its great use to man and beast and its easily recognizable characteristics it is referred to in some of our earliest records. Salt is referred to in the ninth book of Homer's Iliad, two hundred and fourteenth line (as early as the ninth century B. C.): "He sprinkled the meat with divine salt." In a second passage, about the same time, it is said: "You would not give even as much as a grain of salt to your suppliant." (The seventeenth book of the Odyssey, line 455.) Borysthenes, in Herodotus, fourth book, fifty-third chapter, in regard to the river Neber, in southern Russia, says: "And salt formed in great plenty about its mouth without human aid." The date of the above was about 450 B. C.

In speaking of northern Africa in the same book, chapter 185, he says: "Along northern Africa, (speaking of the country west of Egypt running as far west as the Straits of Gibraltar or Pillars of Hercules), throughout the whole distance, at the end of every ten days' journey there is a salt mine with people dwelling around it, who all of them build their houses with blocks of the salt. No rain falls in these parts of Libya; if it were otherwise the walls of these houses could not stand. The salt quarried is of two colors, white and purple." We also have a very early record of the manufacture of salt given in the sixth book of Herodotus, chapter 119. Speaking of a place in Persia at Ardericea, which was about twenty-five miles from Susa, he says: "About five miles from this Ardericea from which they got bitumen, salt, and oil, which they drew up with a sweep and a wineskin bucket. They then poured the liquid into a reservoir from which it passed into another, where the salt and bitumen collected and hardened, while the oil is drawn off into casks."

We also find a reference made in the seventh book, chapter 30, of "a lake from which salt is gathered" in Phrygia, in Asia Minor.

Although salt is indispensable to us at the present time as an appetizer and for curing meat, etc., it was prized much more highly by the ancient Hebrews. They used it as an accompaniment to their various offerings made on the altar. Leviticus ii, 13: "And every oblation of thy meat offering shalt thou season with salt; neither shalt thou suffer the salt of the covenant of thy God to be lacking from thy meat offering; with all thine offerings thou shalt offer salt."

The present inhabitants at the south end of the Dead sea possess an inexhaustible and ready supply of salt. II Samuel viii, 13, gives evidence of its existence in ancient times: "And David gat him a name when he returned from smiting of the Syrians in the valley of salt, being eighteen thousand men." They also mentioned the salt pits which probably occurred here and were covered with the scale of salt left by the evaporation of water remaining behind from high tide (Zephaniah ii, 9). Here were the successive pillars which tradition has at different times identified with Lot's wife. In Nehemiah xiii, 16, we find the use and perhaps the manufacture of salt had extended over to the Mediterranean sea, for the Phœnicians would naturally obtain the salt used for curing fish and for other purposes by evaporating the sea water. According to Josephus, the salt pits formed a very important source of revenue to the rulers. Antiochus was considered very generous when he gave to the city of Jerusalem 375 bushels of salt to be used in temple service. This product has become a symbol for many important things. On account of its being an essential article of diet, it symbolized hospitality; while as an antiseptic — fidelity, durability, and purity. For this reason, we have the expression, "covenant of salt," as given in Leviticus ii, 13, and Numbers xviii, 19.

It is of interest to notice that the ancients, from observations near the shores of the Dead sea, had noticed and made mention of the fact that an excess of salt produces sterility. Deuteronomy xxix, 23, and Zephaniah ii, 9, exemplify this.

The manufacture of salt in ordinary kettles of various sizes gradually spread along the shores of Europe, Asia, and Africa, as the different races explored and settled these regions. Very naturally this system prevailed until deep borings revealed the great interior brines and the solid rock salt at numerous places in the eastern continent.

History of Salt in America.

Let us trace briefly the development and gradual migration westward of the salt industries in America. The following facts and quotations are gleaned from Frederick J. H. Merrill's report on salt and gypsum industries of New York in the Bulletin of the New York State Museum of April, 1893. About the middle of the seventeenth century, the Jesuit missionaries, in making their journeys among the Indians, in what is now the state of New York, heard of certain springs which were regarded with superstition and said to contain demons. Several of these springs were pointed out to the missionaries and salt was soon manufactured by the Indians and traders. It was not, however, until 1788 that a systematic manufacture of salt was begun in the vicinity of Syracuse. In the winter of 1789 and '90 the total output of this region was between 150 and 200 barrels.

In 1820 the legislature authorized Benejah Byington to bore for rock salt on the reservation, offering a premium for any salt produced. In 1878 rock salt was discovered in New York. Numerous salt wells were bored in this great salt region during the next five years and the rock salt was dissolved with water and taken up as brine. Rock-salt mining in New York, however, dates back only to November, 1885.

Since the first discovery of salt in New York the development of the great Mississippi valley has made a wonderful demand for salt. This industry has made great progress, not only in New York, but also in Michigan, Pennsylvania, Ohio, West Virginia, Louisiana, Kansas, Nevada, Utah, and California.

Geographical and Historical.

A large part of the state of Kansas contains salt at the surface or within easy drilling distance. The area particularly referred to in this report occupies a position near the middle of the state, extending entirely across from the north line to the south, and even beyond into Oklahoma. The salt occurs in two relatively distinct forms: (*a*), As brines in salt marshes, which leave salt on the surface by evaporation in the dry season, producing the so-called salt plains; and (*b*), rock salt, which is found beneath the surface. In addition to this, the greater part of the Permian and Coal Measure shales in the east part of the state have so much salt in them that the water obtained from deep wells is quite strongly saturated with salt and other mineral products.

The salt marshes are found in a zone trending a little east of north

and west of south, reaching from Republic county on the north to Barber county on the south, and even to the Cimarron river in Oklahoma, below Comanche and Clark counties. Republic county has two marshes, the Tuthill in the southeast corner, and the Jamestown marsh, lying partly in Republic, Jewell and Cloud counties, at the extreme southwest corner of Republic county. There are at least two salt marshes in Mitchell county near the southern side, and two well defined marshes in Lincoln county near the northern side. The northeast corner of Stafford county likewise has two marshes, while three prominent and historical marshes have long been known in Oklahoma, known respectively as the East Saline Reserve, south of Harper county, on the Salt Fork of the Arkansas river, Middle Saline Reserve, and the West Saline Reserve, on the Cimarron river south of Comanche county.

The area of Kansas under which rock salt is known to exist is situated in the south-central part of the state. By an examination of the map, Plate IV, the area as known to exist can readily be located by the shaded portions covering part or all of Ellsworth, Barton, Rice, McPherson, Stafford, Reno, Pratt, Kingman, Sedgwick, Harper and Sumner counties. The heavy line, including the shaded area, is drawn from point to point where deep wells have proved the presence of rock salt. It is probable the eastern limit of salt is near the limit of the shaded area, as the salt here comes nearer to the surface and likewise has less thickness than farther to the west and north. The western and northern limits, however, are placed where they are, not because it is thought they represent the extreme extension of the salt beds, but because they connect the westernmost and northernmost points at which deep wells have reached salt. It is probable that the salt extends much farther in these directions than the area indicated on the map.

Numerous reports have been sent out of rock salt being found at other places in the state, particularly in the eastern part. Considerable effort was made to verify these several reports. In each instance, however, as best could be learned, the report started from the occurrence of strong brine in wells. The existence of rock salt in the Coal Measure shales may well be doubted, it would seem, unless more positive evidence is gained than has yet been brought forward.

TUTHILL MARSH.

One of the most important salt marshes in pioneer times was the Tuthill marsh, located in the southeast part of Republic county, as

shown by the map, Plate IV. Prof. B. F. Mudge gave the above name to this marsh in the First Biennial Report of the State Board of Agriculture in honor of the Tuthill (sometimes spelled Tuttle) family, who were early settlers there.

Mr. Tuthill was evidently the pioneer salt manufacturer of Kansas. He was located on the east bank of the marsh, which is a great white plain during a part of the year. In the fall of the year the water is generally nearly all evaporated, and the edges of the marsh are dry and covered with a hard, thin scale of impure salt. Towards the center of the marsh the surface is more moist and the scale of salt less thick and solid. Near the center are found numerous pools of clear, briny water. During the rainy season water collects over the marsh to a depth of a foot or more, coming from the ravines on neighboring hillsides, as well as from numerous seeping springs near the edge of the marsh. In section 28, township 4 south, range 2 west, Mr. T. B. Hazen sunk a well ninety-two feet deep. He passed through sixty feet of loose soil and clay before striking solid rock. At the top of the rock he found a considerable flow of brine, which rose to the top of the ground. It was so strong a brine that it would not freeze in the coldest winter weather. This seems to indicate that the whole region about the marsh is underlaid with subterranean salt waters, which have more or less effect upon the amount of water in the marsh during the dry season.

In this marsh are found a number of varieties of salt-water weeds, which in some cases grow quite luxuriantly, but usually dry up, break off and blow away before the season is over, leaving only great tufts of roots to mark the place of their growth.

These marshes are the center of attraction for sportsmen during the season for ducks and geese. It is stated by poineers that great quantities of buffalo, deer and antelope bones were found upon the marshes in early times. This, together with the numerous deeply worn paths, showed that the wild animals of the plains had for many ages secured their salt at these marshes.

In the manufacture of salt, Mr. Tuthill would collect the salt scales from over the marsh and dissolve them in water, allow the earthy impurities to subside, and siphon off the clear brine and evaporate it to dryness to recover the salt and other impurities. When the weather was not favorable for the formation of salt scales over the marsh, he would dip or pump the brine from small wells and haul it to his little salt factory. The brine was evaporated from large kettles, in much the

same way that our fathers evapored sugar water in Indiana, Ohio, and the Eastern states. At present this seems like a very primitive method, but at that time it was in accordance with the most approved process. Portions of the arch of Mr. Tuthill's kettle salt plant still stand to mark the spot of his primitive factory.

In the early sixties Mr. Tuthill made salt and hauled it to Manhattan, where he received as high as ten cents per pound for it. Mr. Hazen says he sold over 100 barrels of salt made by Mr. Tuthill and other farmers from 1873 to 1876, while he kept a store in Seapo.

This marsh and other similar ones of the state were of great value to hunters in early times. They would come here to "jerk" their buffalo meat. In case they were in too great a hurry to wait to evaporate the brine and get the crystallized salt, they would dip the meat and hides into the strongest pool of brine and then dry them in the sunshine or by a fire. When a considerable quantity of meat was to be "jerked," they would cut the meat into long strips, boil the brine in kettles hung over a fire of buffalo chips, dip the meat into the strong, hot brine, lay it out to dry in the sunshine or on a lattice-work made of green poles supported on four posts with a fire under it. In this way 200 or 300 pounds could be cured in five or six hours.

THE JAMESTOWN MARSH.

Near the corner of Jewell, Republic and Cloud counties is a large salt marsh, the most of which is in section 5, township 5 south, range 5 west. This, together with the Little marsh in sections 17 and 18, township 5 south, range 4 west, have the same general characteristics as those given for the Tuthill marsh.

LINCOLN COUNTY MARSHES.

Mr. D. R. Mosher, of Beloit, gave the names of several men whom he had helped when a boy to "jerk" buffalo hams with the salt made by boiling the brine from the marshes in northern Lincoln county, and the one on Salt creek, in Mitchell county. It seems that the manufacture of salt at this place did not reach beyond the local demand. The Lincoln county marshes, on Rattlesnake creek and at the junction of Battle creek and Prosser creek, are narrower and of less importance than the Jamestown and Tuthill marshes.

STAFFORD COUNTY MARSHES.

As shown by the map, Plate IV, there are two marshes in Stafford county, known as Big marsh and Little marsh. These marshes were not only used in early times for the curing of venison, but a little

salt plant was erected, and quite a quantity of salt was produced about 1878. The product came from a spring at the south part of the Big marsh. The building or factory was about 30x40 feet, and the brine was boiled with wood taken from the neighboring sand-hills. The product was hauled to Great Bend as early as 1867, but there being no railroad there at that time it did not prove to be a profitable business. Here, as elsewhere, only a few cinders and fragments of brick remain to mark the place of this primitive factory.

EAST SALINE RESERVE.

The three Saline Reserves, East, Middle, and West, of Oklahoma, or rather the Cherokee strip, are closely allied in character to those of Kansas, and will therefore be mentioned in connection with them. The East Saline Reserve is located on the Salt Fork of the Arkansas river, a little below the mouth of the Medicine river. This marsh is the largest of any in the "strip," and larger than any in Kansas. It is about fourteen miles in length from north to south and eight miles from east to west at the widest point. It is known throughout this whole county as the Great Salt Plain.

MIDDLE AND WEST SALINE RESERVE.

The most important and valuable salt marsh or plain of this whole region is the one on the Cimarron or Red Fork of the Arkansas river at the mouth of Buffalo creek, as shown on the map, Plate IV. The West plain is a few miles farther up the Cimarron, but it is small and of minor importance. The Middle plain is about forty miles southwest of Alva, Okla. It covers a large part of two sections on the Cimarron river and Buffalo creek. On the south side of Buffalo creek are some very strong salt springs, and here and there are numerous places where the strong brine bursts forth and runs into a second little stream, or disappears in the sand.

Along the edges of the little streams and around sticks and weeds and other foreign objects beautiful films of salt crystals form, often being six or more inches across, when finally they become too heavy for their support and fall to the bottom. During the dry season the brines from the springs are so concentrated that they deposit rock salt over the whole surface of the marsh. The wind-blown sand soon covers the salt to a depth of several inches or even feet. In early times the Indians, and later the stockmen, came here and hauled away the salt in large quantities, taking it to various places in the Indian territory and Kansas. Maj. J. D. Miles, of Lawrence, Kan., formerly

Indian agent for the Cheyenne and Arapahoe tribes, says that they hauled salt from this salt plain to their agency near Fort Reno. The cattlemen also came here from many miles around for their supply. Even since the railroad has brought cheap Kansas salt into the "strip" the settlers and ranch men for thirty or forty miles around continue to get their salt here. But this product will probably never be prized as highly in the future as it has been in the past.

Prophecy of Professor Mudge.

In the biennial report of the Kansas State Board of Agriculture for 1877–'78, Professor Mudge makes the following statement: "The great supply of salt which is to furnish Kansas and the neighboring states is at various points in a tract of country, about thirty-five miles wide and eighty long, crossing the Republican and Saline valleys. The indications of the deposit are seen in numerous springs, but more frequently in extensive salt marshes." Although Professor Mudge's prophecy in regard to the region just described has been fulfilled, it is interesting to notice that the facts from which he drew his conclusions have nothing at all to do with the great salt beds of Kansas, which now supply such large quantities of salt.

Ordinance of the Constitution of the State.

Previous to the admission of Kansas into the union as a state the salt marshes were thought to be of such great value that by act of congress twelve salt springs were donated to the new state at the time of her admisson, the same to be located by her commissioners. They were all located on marshes, and have no marked flowing springs. Subsequently these reserves were given by the state to the endowment fund of the State Normal School. The following is taken from the ordinance of the constitution of the state of Kansas:

"WYANDOTTE, KAN., July 29, 1859.

"(78) *Salt Springs.* § 5. That all salt springs not exceeding twelve in number, with six sections of land adjacent to each, together with all mines, with the land necessary for their full use, shall be granted to the state for works of public improvement."

Solomon City Salt.

From the earliest settlement of the state, numerous briny wells have been found throughout the Carboniferous area which covers the entire eastern part of the state. None of these have been of any great importance at any time, although some salt has been produced from

those at Alma, St. Mary's, Osawatomie, and Junction City. Almost every deep well in this whole region has struck more or less salt water, but none of them have been of any marked commercial importance. The most important brine wells, and in fact the only successful ones, are located at Solomon City, in Dickinson county.

The early history of these wells is interesting. Wm. Taylor, of New Bedford, Mass., came to Solomon City in 1866, and looked over a large area of land with a view to speculation. When he had returned to Solomon City from a long and unsatisfactory trip, he bought his stage ticket, preparatory for returning home. He called on Mr. R. N. Wimsatt, at his place of business, to bid him good-by. The stage being two hours late, and learning of his mission, Mr. Wimsatt told him of a salt spring just west of town. A hurried examination was made of the spring and surrounding conditions and the situation talked over. Nothing more was heard from Mr. Taylor until 1867, when C. W. Davis, of New Bedford, Mass., as the representative and superintendent of the Continental Salt Company, arrived in the village with a full set of drilling tools. The first well was drilled in town. It produced some very good brine.

This company soon sold out to Jos. H. Wood and L. L. Baker, who operated the salt plant until 1877. In 1874 Mr. Wm. Dewar, of Ohio, began prospecting for salt, which resulted in the location of the present well. He struck very good brine at 84 feet, but went on down to about 100 feet. He built a solar plant, which he operated during the seasons of 1874 and 1875, under the name of the Wimsatt salt works. Brooks and Brown, of the West Virginia salt works, operated it during the years 1876 and 1877.

In 1880 the National Solar Salt Company began operations, and in 1881 the two plants were merged into one, and this company operated them until 1885. It was practically closed until 1888, when Mr. Wimsatt operated it first for R. J. Weemys and later for R. W. Wirt. In 1890 it became the property of the present owner, the Solomon Solar Salt Company.

As can be seen from the above this plant has gone through numerous changes and the work has been very irregular. But this little factory has caused Kansas to be recognized among the salt-producing states of the union. Mr. Cowie, the present superintendent, says they have a capacity of about 7000 barrels per year.

The Solar Process Salt Plant of Solomon City.

Discovery of Rock Salt in Kansas.

In 1887 and 1888 central Kansas was undergoing a wonderful change and development. Farms were being developed, factories were springing up, cities were building all modern improvements and struggling for superiority in every line. Ready cash was at hand for any and all kinds of speculation. Companies and syndicates, with many thousands of capital, were formed in a few hours to undertake the most daring enterprises. Settlers were swarming in by the thousand from Missouri, Iowa, and the Eastern states. It was during this period of boom that Ellsworth, Lyons, Hutchinson, Great Bend, Kanopolis, Pratt, Nickerson, Sterling, Kingman, Anthony and Wellington organized companies to bore for coal and gas, or any valuable mineral that might chance to be found. In the fall of 1887 and during the year 1888 rock salt was struck at the above towns. In most cases they were seriously disappointed in not finding either coal or gas in large quantities, and they were slow to appreciate the real value of such an important mineral as rock salt.

ELLSWORTH.

Early in the year 1887 the Ellsworth Mining Company was formed for the purpose of prospecting for coal, gas, or any other valuable mineral. The first money was paid in and work began about the 1st of August of that year; they located a well just outside the northwest limits of the town. At 250 feet water raised almost to the surface, and at this stage artesian water received considerable comment. Greatly to the surprise of all interested rock salt was struck September 5 at a depth of 728 feet. A company was organized which began putting down a shaft. When it had reached a depth of 250 feet the funds gave out, and while this company waited other points with more favorable railroad facilities were taking the lead, and Ellsworth was so far behind that the shaft was never completed. The following affidavit contains a number of points of interest in regard to the operators and the promoters of this great enterprise:

"State of Kansas, Ellsworth county, ss.

"THIS IS TO CERTIFY, That in drilling a well for the Ellsworth Mining Company, near Ellsworth, Kan., a vein of rock salt was struck at a depth of 730 feet from the surface, and continued solid rock salt until a depth of 880 feet was reached, except five feet of light gray slate at a depth of 785 feet, being a solid bed of rock salt 145 feet thick.

H. G. JOHNSON, *Contractor.*
E. H. AKIN, *Superintendent.*

"Archie Huycke and Joseph Cochrane — those two men were watchers; James Kenehean, driller.

"Subscribed and sworn to before me, this 17th day of September, A. D. 1887. C. F. POHLMAN, *Notary Public.*

My commission expires August 29, 1891.

"We believe the above affidavit to be true, and certify that a good flow of gas was struck at 1195 feet.

G. W. CLAWSON, *President.*
W. F. TOMPKINS, *Vice-President.*
H. F. HOESMAN, *Secretary.*
JOHN PRESSNEY, *Treasurer.*
J. E. LLOYD, *Attorney.*"

HUTCHINSON.

Notwithstanding the many evil effects of town booms, it is probably to this one thing that Kansas is indebted for taking an important rank so suddenly among the leading salt-producing states of our union.

During the year 1887, Mr. Ben Blanchard, a prominent citizen of the place, started a prospect well in the edge of the little city of South Hutchinson. The well was started for gas, oil, coal, or any valuable mineral whatever. At first Blanchard was promised liberal support by several citizens. The work went on from day to day without any encouraging results and his would-be supporters refused to give it further support. He immediately put a tight fence around the drilling machinery and no one was allowed to see the results as the work progressed.

The secrecy of the prospecting paved the way for great excitement when at last they announced that salt was found. Day after day the drill pounded on the rock salt until at last it was entirely penetrated, and they struck a little oil. When the oil was announced excitement became intense. The prospector himself did not at first realize the vast importance of his discovery of rock salt. When the real value was determined and the results of the prospect well published, the immense thickness of the salt bed was doubted. It was difficult to believe that only 500 feet below the surface was to be found a bed of salt almost 400 feet in thickness.

The New York salt companies were the first to realize the real value of this discovery. Guinlock & Humphrey, of Warsaw, N. Y., came and looked over the ground, and soon had two wells drilled and a salt factory erected. From this beginning the manufacturing industry has grown, until in 1898 Kansas produced nearly 2,000,000 barrels of salt, more than ninety per cent. of which was made at Hutchinson.

LYONS.

The enterprising citizens of Lyons organized the Natural Gas, Oil and Mineral Company, and began sinking a prospect well in November, 1887. On December 2 of the same year, rock salt was struck at a depth of 793 feet, which was 275 feet in thickness. This town was able to distribute its product by means of the Atchison, Topeka & Santa Fe, the Missouri Pacific, and the St. Louis & San Francisco. So ardent was the support of the citizens that at one time it looked as if Lyons would be the greatest salt city of the state, but water was more easily procured in the Arkansas valley, and thus the salt wells were mostly located there.

In 1890 some of the principal bankers and business men of Lyons, and a few from St. Louis, organized the Lyons Rock Salt Company for the purpose of sinking a shaft and opening the rock salt mine. Work was commenced August, 1890, and the salt was reached the following January. A little later the Midland Salt Company put down a shaft to the salt bed, but the mine was never developed, and the shaft filled with water to day is entirely destroyed. The construction and the capacity of the mine at Lyons will be discussed in another chapter. An excellent illustration of this splendid plant is given in Plate XI.

KINGMAN.

The Kingman Light and Fuel Company was organized and began prospecting in May, 1887. According to the account given by the county surveyor, W. H. Childs, rock salt was struck the following July. This enterprising little city had appropriated $5000 for prospecting purposes, so they went on through the salt in the hope of finding gas or oil.

The Kingman Rock Salt Company was organized early in 1888, and began work on a $4\frac{1}{2}$x$8\frac{1}{2}$ shaft in May. The shaft was completed and the building erected ready to hoist salt the following spring. The mine was in active operation for about two years, but at present the machinery is gone and the mine is filled with water.

The early history of the Kingman Salt Company was so flattering that a Chicago company, known as the Crystal Rock Salt and Mining Company, put down a 14x16-foot shaft. This company put up a much larger building than the former, and equipped it with the most improved machinery, from the Vulcan Iron Works, of Pennsylvania. In 1893 this company failed, and the Vulcan Iron Works had to take the plant. It has not been in operation since that time, and the mine

The Lyons Rock Salt Plant.

soon filled with water and is now a total wreck. During the summer of 1890 four salt plants for evaporating brine were erected in the south part of Kingman, viz., the Stout & Babcock salt plant, the Crystal plant, the Moore plant, and the Easley plant. The first has been torn down, and the second is at present almost a wreck, while the third and fourth enjoy good business at present.

RAGO.

At Rago, a little town between Kingman and Harper, a well was put down over 1000 feet, in the year 1888. They penetrated 100 feet of rock salt which was of an excellent quality. Owing to the experience of some investors in other towns they were unable to interest capitalists sufficiently to get them to put in a plant.

ANTHONY.

In 1887 a prospecting company was formed in Anthony to search for coal and gas. At 946 feet they reached the salt beds which continued to the depth of 1350 feet, and they extended the prospect well to 2335 feet, as shown by Plate VII. It seemed that the opportunities for starting a salt plant at this place were very good and in 1888 the Anthony Salt Company erected a four-pan plant. This was never a very profitable investment and it continued in operation for part of the three years following.

A little later the Globe Salt Company erected a two-pan plant. They made salt for about five months during the season of 1889. Since that time the plant has been closed and was finally destroyed.

WELLINGTON.

At the time the prospecting fever struck all the other towns to the north and west, Wellington was abreast the times and put down a prospect well. To their great surprise salt was struck at 240 feet, but at this place the bed is only 50 feet in thickness. A company was soon organized and a small one-pan plant was erected in 1888. This company, like many others, was compelled to give way to other larger and stronger companies more favorably located.

NICKERSON.

In the fall of 1888 Palmer & Davis, of Hutchinson, completed a a salt well for the Nickerson Salt Company, and a plant was immediately erected. Operations were begun the fall of 1888 and the plant was in operation a large part of the time until March 4, 1891, when it was sold to the Hutchinson Salt Company. Since that time it has

been closed. During the years 1889 and 1890 they enjoyed a large and prosperous business.

STERLING.

As an excellent bed of salt had been found north of Sterling, at Lyons, and at several points to the east, a salt well was put down here, and the old beet-sugar factory turned into a salt plant.

The Sterling Salt Company also put down a well and erected an excellent two-pan plant. The former was in operation but a short time while the latter has been actively engaged in the manufacture of salt almost ever since it began—January 1, 1891. The Sterling Salt Company has recently gotten control of the old sugar factory plant, and in the future they will operate and control both.

KANOPOLIS.

Kanopolis, a thriving little town situated on the historic spot of old Fort Harker, put down a well early in the period of prospecting for salt elsewhere. Following this they put in an excellent shaft, and have been producing rock salt in great abundance ever since. The machinery and plant will be discussed in detail in another chapter.

GREAT BEND.

During the summer of 1887 the Great Bend Gas and Fuel Company was organized, with Capt. J. F. Lewis as president. They began drilling an eight-inch hole three miles north of town, in section 13, township 19, range 13. At a depth of 1202 feet they struck the great salt bed, which was penetrated 163 feet. After an expenditure of about $3800 in getting J. S. Wiser, of Cleveland, Ohio, to drill the hole, they abandoned hope of finding either coal or gas. They found an abundance of artesian water at 744 feet, which ran out of the casing thirty feet above the surface of the ground.

WILSON.

In April, 1889, the city of Wilson began drilling a prospect well. At a depth of 740 feet a bed of salt 300 feet in thickness was reached. At 1350 feet sufficient gas was found to burn in a blaze to the height of ten feet but not enough to be of any commercial value. As coal and gas were the all-absorbing questions, this immense bed of excellent salt was not very highly appreciated.

ARLINGTON.

In 1887 the Arlington Prospecting and Mining Company put down a prospect hole to the depth of 1000 feet. At a depth of 600 feet they

TABLE XXIV.

GIVING THE NAMES OF KANSAS SALT COMPANIES AND THE CAPACITY OF THEIR WORKS IN 1888.

After Hay, from U. S. Mineral Resources, 1888, p. 609.

Names of Companies and Location of Works.	Wells.	Depth of wells.	Date of first production of salt.	Number and dimensions of evaporating pans.		Employees.	Total daily capacity of the works.	Annual output of salt, up to November 30, 1888.
				No.	Dimensions.			
HUTCHINSON.		*Feet.*					*Barrels.*	*Barrels.*
Guinlock & Humphrey	2	800	Mar. 15, 1888	4	70 x 25	40	600	70,000
Hutchinson Salt and Manufacturing Company	2	450	Oct. 4, 1888	2	115 x 26	28	200	10,000
Crystal Salt Works	1	796	Oct. 15, 1888	2	115 x 26	25	300	820
Riverside Salt Company	2	775	Nov. 1, 1888	......	100 x 26	40	600	§ 17,500
New York Salt Company	1	786	Nov. 23, 1888	2	115 x 26	17	400	1,000
Hutchinson Solar Salt Company	1	830	*	500	16 x 16	......	200	....
Hutchinson Salt Company (grainer process)	1	800	*	2	90 x 26	15	250	....
Western Salt Company	2	700	*	4	115 x 26	50	500	....
Diamond Salt Company	1	765	Oct. —, 1888	2	125 x 26	30	400	§ 20,000
Pennsylvania Salt Company	1	806	*	2	125 x 26	22	450	....
Bartlett Salt Company (grainer process)	1	700	*	1	90 x 26	11	150	....
Vincent Salt Company	2	750	Dec. —, 1888	4	100 x 25	5	750	....
OTHER PLACES.								
Anthony Salt Company	1	1,000	Dec. —, 1888	4	80 x 25	......	600	....
Globe Manufacturing Company, Anthony	1	100	*	2	85 x 25	......	350	....
Nickerson Salt Company	1	800	*	2	....	25	350	....
Solomon Solar Salt Works	2	200	——, 1867	......	† 370,000	6	‡ 10,000	....
Sterling Salt Company	1	916	*	2	90 x 22	25	400	....
Wellington Salt and Mining Company	1	290	Dec. 3, 1888	1	70 x 26	11	158	§ 3,100
Great Bend Salt Company	2	1,400	*	2	84 x 25	30	400	....

* Not commenced. † Area in feet. ‡ Per annum. § To December 31, 1888.

struck the salt bed, and when they quit, at the depth of 1000 feet, they were still in salt. This hole was about one-fourth mile north of town and nothing has been done with it since it was finished.

LITTLE RIVER.

During the summer of 1895 a prospect well was put down in the northwest part of the town of Little River. This was undertaken with the idea of sinking a shaft at this place. The bed of salt was found to be of excellent quality, but the shaft has not been sunk.

GEOLOGY OF KANSAS SALTS.

BY ERASMUS HAWORTH.

In discussing the geology of Kansas salts, it is desirable to divide the salt beds into two groups dependent upon their position, as was done earlier in this report in discussing the geographical position of salt. The sources of salt in the salt marshes and salt plains is quite different geologically from that of the rock salt, and will therefore be considered separately.

Salt Marshes.

The salt marshes in the northern part of the state, and possibly as far south as Stafford county, obtain their salt from the saliferous shales of the Dakota formation. In Volume II, page 209, Logan has given a concise account of these salt-bearing shales, in which he describes them as located near the base of the Upper Dakota. They rest upon the lignite division, which is principally a grey or white sandstone formation, and which produces the lignite coal found in Mitchell, Lincoln, Russell and Ellsworth counties. They are from fifteen to thirty feet in thickness. Their eastern limit or outcropping is marked by a sinuous line crossing the greater part of the state north of the Arkansas river from Republic county on the north to Barton county on the south, and even beyond to the southwest.

On account of their highly saliferous character these shales are particularly subject to erosion, and have been important factors in the production of many of the low, marshy areas so common to that part of the state, an extreme representation of which is the great basin a few miles north of Great Bend. The salt marshes represent in most cases, first, a low, level area produced by erosion of these shales, and second, a mass of brine which has received its salt by the rain-water leaching the latter from the adjacent shales to the west. In some cases the brine seems to reach the surface in the form of deep-seated springs, while elsewhere it is an ordinary hillside spring. It is quite possible the other horizons in the Dakota assist in supplying salt for the salt marshes, as they are known to be slightly saline. But the saliferous shale beds are the principal producers.

There may be a little doubt regarding the source of the salt in the Stafford county marshes. The surface of the country here is so mantled by the Tertiary and river sands and gravel that it is difficult

to make accurate observations regarding conditions beneath. The Red Beds, further to the south, now considered as Upper Permian, are known to be saline throughout their whole thickness. The salt of the marshes in the Cimarron river area and the Salt Fork area comes from the Red Beds, being produced by rain-waters leaching the salt from near the surface in the gradual process of erosion. The Red Beds are known to extent northward under the Tertiary covering to beyond Stafford county. It is therefore somewhat difficult to decide from which source, the Red Beds or the Dakota salt shales, the marshes are supplied.

Rock Salt.

The geology of the rock salt of central Kansas is now pretty well understood. Professor Hay was the first to locate the rock salt in the Permian formation, and to give the name "salt shales" to the horizon containing it. By an examination of the two geologic sections, Plates V and VI, the first extending from Arkansas City to Great Bend, and the other from Oklahoma through Anthony, Kingman, Sterling and Lyons to Kanopolis, the exact position of the salt beds in relation to other well known Permian horizons may well be understood. It is seen that they occupy a position intermediate between the Marion shales and limestones below and the Wellington above.

In the Flint Hills area, where Prosser has studied the Permian so extensively, the salt beds seem to be entirely wanting. From the distance beneath the surface at which the salt is found and from the thickness of the salt beds at different places in an east and west direction, as shown on Plate V, it will be seen that they gradually grow thinner eastward to beyond the limits of Wellington and Little River, and without doubt gradually vanish, possibly even without coming near the surface. The salt springs of Geuda Springs, however, derive their supply principally from this horizon.

In an east and west line the thickness of the salt therefore varies, but how far westward it extends is entirely unknown. The eastern limit of the great salt lake or inland sea from the waters of which this salt was precipitated is moderately well known, while we are yet in total ignorance regarding its western extent. In the north and south direction our knowledge covers a little wider area, reaching from Anthony on the south to Kanopolis on the north. By an examination of Plate VI it will be seen that the salt beds at Anthony are 404 feet thick; at Kingman they are 415 feet thick; at Hutchinson they have

dropped to 380 feet—although it should be stated that the exact thickness varies slightly in different well records—while at Lyons they have decreased to a thickness of 275 feet, and at Kanopolis to one of 250 feet. At this rate of decrease from Hutchinson northward they would entirely disappear before the north line of the state is reached.

A number of interesting facts may be gleaned from a study of these geologic sections, only a few of which will be noted here. Plate VI shows conclusively that Hutchinson rests on the summit of an anticlinal ridge, and that the same anticlinal is present in the overlying Wellington shales, and possibly in the Red Beds, although the stratification of the latter is so irregularly marked that one could not be positive on this point. The anticlinal ridge so conclusively shown to exist at Hutchinson probably is the eastern extension of the anticlinal in the eastern part of the state, trending in the main from east to west, passing through Bourbon, Allen, Woodson and Greenwood counties—the anticlinal frequently referred to in discussions of the geology of the Coal Measures.

By referring the position of the salt beds to the present sea-level it will be seen that this anticlinal must have been produced since the formation of the salt beds. The bottom of the basin in which these were formed must have been concave upwards, but here it is now convex upwards. As the Wellington shales are thinnest immediately over the apex of the anticlinal and grow thicker both north and south, one would be led to surmise that the folding producing the anticlinal ridge began during the Wellington shales period, but such a conclusion can hardly be drawn from the general appearance of the geologic section.

Another most interesting question in connection with the geology of the salt beds is their relation to the extensive gypsum deposits in different parts of Kansas and of the great plains area. By reference to Plate II in Volume V of this series of reports, a Special Report on Gypsum, it will be seen that the rock gypsum in the northern part of the state, in Marshall county, lies but a few feet above the Cottonwood limestone, which would place it considerably below the Marion formation. Passing southward to the central gypsum field, Plate III of the same report shows that rock gypsum occurs in the Wellington shales. If, therefore, the correlations made by Grimsley in the volume referred to are correct, the salt beds were deposited at a period of time intermediate between the formation of the Marshall county rock gypsum and that in the vicinity of Solomon.

It is difficult to understand how such extensive deposits of salt could be formed without a larger amount of gypsum being formed underneath them. The records of the wells at Kanopolis, Lyons, Hutchinson, Kingman and Anthony contain no reference to gypsum immediately underlying the salt beds. The question is as to what became of the calcium sulphate held in solution by the ocean water from which the rock salt was obtained. It is barely possible that during the period of the formation of the Marshall county gypsum the inland sea did not reach southward to the salt beds area, and that after the gypsum was principally precipitated out of the enclosed ocean water and before concentration was carried far enough to precipitate the salt, surface movements resulted in draining this partially purified water southward over new areas from which fresh ocean water was excluded, thus permitting the continued evaporation to deposit the salt now found in the salt beds from the same water from which the Marshall county gypsum was produced. It is known that the Permian rocks, in general, become quite thin northward, entirely excluding the upper members of the Permian. So far as this has a bearing on the subject it would tend to favor the view just expressed.

Subsequent to the formation of the salt beds fresh ocean water must have been admitted to the great inland sea from which was deposited the gypsum of Dickinson county and other counties to the south as far as Sumner. The Wellington shales are largely gypsiferous and saliferous throughout, although no marked beds of rock salt have been found in them. Near the upper surface they change into the Red Beds. Sufficiently detailed examinations in the field have not yet been made to determine how gradual this change is, but as far as observed it would seem the change is moderately rapid.

When the Red Beds period was finally ushered in a series of vacillating conditions must have obtained. The red color of the clays and sandstones implies a total absence of life in the ocean water under which the deposits were collected, and is best explained by assuming that the degree of concentration was so great that life could not be maintained within it. On the other hand, the absence of heavy beds of rock salt within the Red Beds argues with equal strength that at no time was the degree of concentration sufficiently great to precipitate all the salt from the water.

Such conditions may be explained in two ways: (*a*), That the rainfall was sufficiently great to maintain the water above the saturation point; and (*b*), that occasional additions of fresh ocean water were

made to the inland sea, thereby supplying sufficient water to prevent a degree of saturation required for the precipitation of salt. This latter position is favored by the existence of heavy beds of gypsum near the middle of the Red Beds, covering so large an area in Barber and Comanche counties. The absence of heavy gypsum deposits below and above this horizon would seem to favor the fresh-water dilution of the inland sea. It is probable that both conditions obtained.

RECORDS OF SALT WELLS.

The following records of deep wells drilled in the salt region are interesting and important. They were all gathered by Mr. Kirk.

Anthony Well.

In southwest quarter section 19, township 33 south, range 6 west. From a special edition of the Anthony *Republican*, June 25, 1888. (See also Plate VII.)

No.	Material.	Thickness.	Depth.
1	Rich surface loam	9	6
2	Red subsoil	12	21
3	Red rock with fresh water at thirty feet from surface	170	101
4	Blue shale	45	236
5	Red rock	315	551
6	Blue shale with salt brine, water vein at 785 feet	340	891
7	Red shale	30	921
8	Blue shale	25	946
9	Rock salt	275	1,221
10	Gas sand with small flow of gas	139	1,350
11	Rock salt and shale	139	1,465
12	Limestone	115	1,465
13	Black shale	25	1,490
14	Limestone, second salt-water vein at 1600 feet	115	1,605
15	Shale	35	1,640
16	Limestone with salt-water vein	55	1,695
17	Gypsum	20	1,715
18	Black shale	38	1,753
19	Limestone with salt-water vein	82	1,835
20	Soft limestone	55	1,890
21	White shale	40	1,930
22	Limestone	87	2,017
23	Black shale	28	2,045
24	Gypsum	20	2,065
25	Soft limestone	150	2,215
26	Black slate	35	2,250
27	Red magnesia	22	2,272
28	White shale	38	2,310
29	Limestone	25	2,335
	NOTE.—Strongest flow of brine at the bottom yet struck.		

Kingman Well.

Drilled for the Kingman Light and Fuel Company, June and July, 1887, one and one-half miles north of Kingman. Record reported by County Surveyor W. H. Child.

No.	MATERIAL.	Thickness.	Depth.
1	Red rock	100	100
2	Blue-white shale	20	120
3	Red rock	175	295
4	Blue gypsum	10	305
5	Mixed red and gypsum	145	450
6	Blue shale	135	585
7	Brown soft shale	5	590
8	Blue shale	70	660
9	Hard blue rock	5	665
10	Salt and shale	165	830
11	Limestone	5	835
12	Salt and shale	165	1,000
13	Limestone	5	1,005
14	Salt and shale	23	1,028
15	White limestone	8	1,036
16	Oily shale	9	1,045
17	White limestone and shale	10	1,055
18	White limestone and shale	6	1,061
19	Blue shale	4	1,065
20	Flinty marble	5	1,070
21	Salt, shale, and shelly rock	10	1,080
22	Limestone	15	1,095
23	Limestone and shale	30	1,125
24	Limestone	35	1,160
25	Shale	5	1,165
26	Limestone	5	1,170
27	Shale	5	1,175
28	Shale	7	1,182
29	Shale	3	1,185
30	Limestone	12	1,197
31	Shale	13	1,210
32	Limestone	10	1,220
33	Oil sand and shale	5	1,225
34	Shale and limestone	10	1,235
35	Shale	5	1,240
36	Limestone	3	1,243
37	Sandstone	12	1,255
38	Shale and sandstone	30	1,285
39	Blue shale	5	1,290
40	Shale	5	1,295
41	Red shale	9	1,304
42	Sandstone	6	1,310
43	Sandy shale	10	1,332
44	Buff sandstone	8	1,340
45	Shale	6	1,346
46	Brown sandstone	24	1,370
47	Sandy shale	5	1,375
48	Buff shale	20	1,400
49	Buff shale	10	1,410

The Hutchinson (Ben. Blanchard) Prospect Well.

South of the river. Record furnished by the drillers, Messrs. Palmer & Davis.

No.	Material.	Thickness.	Depth.
1	Sand, drift and soil	146	146
2	Red shale	26	172
3	Shale	2	174
4	Red shale	76	250
5	Blue shale	12	262
6	Grey shale	78	340
7	Red shale	10	350
8	Black shale	15	374
9	Red shale	9	383
10	Black shale	4	387
11	Black shale	95	482
12	Salt	18	500
13	Shale	8	509
14	Shale and salt	3½	512½
15	Salt	13	525½
16	Shale	7½	533
17	Shale	5½	538½
18	Shale	2	540½
19	Salt	11	551½
20	Shale	7	558½
21	Salt	10	568½
22	Shale	3½	572
23	Salt	27	599
24	Flint rock	2	601
25	Salt	47	648
26	Shale	3	651
27	Salt	138	789
28	Shale	13	802
29	Salt	8	810
30	Shale	37	847
31	Gypsum	28	875
32	Lime	38	913
33	Marble	3	916
34	Clay	1	917
35	Shale	4	921
36	Gypsum	8	929
37	Black shale	5	934
38	Limestone	6	940
39	Red shale	2	942
40	Limestone	19	961
41	Shale	11	972
42	Limestone	10	982
43	Black sandstone	7	989
44	Limestone	24	1,013
45	Sandstone	27	1,040
46	Shale	22	1,062
47	Limestone	14	1,076
48	Shale	25	1,101
49	Red sandstone	45	1,146
50	Limestone	12	1,158
51	Shale (small seam coal)	36	1,194
52	Limestone	26	1,220
53	Sandstone	35	1,255
54	Limestone	10	1,265
55	Shale	30	1,295
56	Limestone	5	1,300
57	Shale	7	1,307

Shaft of the Lyons Rock Salt Company.

Lyons. (See Plate IX.) Reported by Supt. Jesse Ainsworth, a record without doubt the most perfect in the whole salt region, as it was a large shaft, and the superintendent was very careful to keep an accurate record.

No.	MATERIAL.	Thickness.	Depth.
1	Soil and sandy loam	30	30
2	Sandy loam	15	45
3	Sandstone	10	55
4	Variegated clays	12	67
5	Blue clay	13	80
6	Black shale	30	110
7	Grey sandstone	10	120
8	Red sandstone	78	198
9	Red sandy shale	56	254
10	Red clay	18	272
11	Soft limestone	3	275
12	Gypsum and limestone	9	284
13	Blue shale	4	288
14	Red shale and blue shale mixed with gypsum	292	580
15	Dark grey shale	60	640
16	Reddish grey shale	30	670
17	Dark grey shale	123	793
18	Light grey salt rock	2	795
19	Dark grey salt and rock	½	795½
20	Light grey salt rock	1½	797
21	Light grey salt rock	1	798
22	Dark grey salt rock	4	802
23	Light grey salt rock	3½	805½
24	Reddish grey salt rock	½	806
25	Grey shale	8	814
26	Dark grey salt rocks	8½	823
27	Dark grey salt rock	2	825
28	Grey shale and salt, mixed	3	828
29	Grey shale	4	832
30	Light grey salt rocks	9	841
31	Rock salt and shale	1½	842
32	Light grey salt rock	8½	851
33	Grey shale	1½	852
34	Light grey salt rock	8½	861
35	Shale	1	862
36	Light grey salt rock	6½	868
37	Shale and salt rock, mixed	2½	871
38	Dark salt and shale	8½	879
39	Crystal salt	4	883
40	Shale and salt	7	890
41	Dark salt and shale	2½	893
42	Dark salt and shale	16	909
43	Dark red shale	6	915
44	Dark salt and rock	10	925
45	Dark salt with crystals	17	942
46	Rock and salt and shale	19	961
47	Dark salt and shale	21	982
48	Crystal salt	2	984
49	Shale	1	985
50	Light grey salt	9½	994½
51	Shale	½	995
52	Light grey salt and a little shale	10	1,005

Kanapolis Well.

Record as furnished by the company: "Boring commenced March 1, 1889; well completed March 16. From surface to first specimen of salt intermingled with slate, 640 feet; thickness of pure salt, 230 feet; actual depth of well, 881 feet. Eight-inch drive pipe, 105 feet; 5⅝-inch casing, 333 feet; ½-inch tubing in the well, 851 feet and 6 inches. Piping placed in the well and the well completed ready to attach pumps, March 18. The fresh-water well for use of drilling was sunk 35 feet, cased with 5⅝-inch casing properly perforated and driven to the bottom, and furnishes an abundant supply of pure water. The following represents the drillings found in every 5 feet:"

No. of feet from surface.	
5.	Soil, sandy loam.
10.	Brown sand.
15.	Yellow "
20.	Sand and fine gravel.
25.	White sand and fine gravel.
30.	" " " "
35.	Coarse gravel.
40.	Yellow clayey sand.
45.	Grey soapstone.
50.	" "
55.	Light grey soapstone.
60.	Red shale.
65.	Pink "
70.	Grey "
75.	" "
80.	Grey sand and gravel.
85.	Grey shale.
90.	" "
95.	" "
100.	" "
105.	" "
110.	" "
115.	Dark blue shale.
120.	" "
125.	" "
130.	" "
135.	" "
140.	" "
145.	" "
150.	Lead-colored shale.
155.	" "
160.	" "
165.	" "
170.	" "
175.	" "
180.	" "
185.	Red shale.
190.	Silica or light shale.
195.	" " soft shale.
200.	" " "
205.	Red triassic rock.
210.	" "
215.	" "
220.	" "
225.	" "
230.	" "
235.	" "
240.	" "
245.	Brown triassic rock.
250.	Dark brown triassic rock.
255.	" " "
260.	Brown and red triassic rock.
265.	" " " "
270.	Dark red triassic rock.
275.	" " "
280.	Brown and red triassic rock.
285.	" " " "
290.	" " " "
295.	" " " "
300.	Dark brown triassic rock.
305.	Red triassic rock.
310.	" " "
315.	" " "
320.	Light red triassic rock.
325.	" " "
330.	" " "
335.	Brown and red triassic rock.
340.	Dark red triassic rock.
345.	" " "
350.	Brown triassic rock.
355.	" "
360.	" "
365.	Dark red triassic rock.
370.	Dark brown triassic rock.
375.	Dark red triassic rock.
380.	" " "
385.	Traces of gypsum.
390.	Dark red triassic rock.
395.	Very dark red triassic rock.
400.	Dark (gypsum) triassic rock.
405.	Brown (traces) triassic rock.
410.	Blue shale.
415.	Blue shale and gypsum.
420.	" "
425.	" "
430	" "
435.	" "
440.	" "
445.	" "
450.	" "
455.	" "
460.	" "
465.	Blue shale.
470.	"
475.	Brown shale.
480.	"
485.	"
490.	Red triassic rock, gypsum.
495.	Brown triassic rock, gypsum.
500.	" " " "
505.	" " " "
510.	Brown shale.
515.	"
520.	"
525.	"
530.	Grey shale.
535.	Brown shale.
540.	"
545.	"
550.	"
555.	"
560.	"
565.	Blue shale.
570.	"
575.	"
580.	"
585.	"
590.	"
595.	"
600.	"

No. of feet from surface.

605. Blue shale.
610. "
615. "
620. "
625. "
630. "
640. Blue shale, with few scales of salt.
645. Blue shale and salt mixed.
650. Black shale and salt mixed.
655. Salt.
660. Salt and shale.
665. Shale and salt.
670. Salt.
675. Salt, bright crystals.
680. " "
685. " "
690. " "
695. " "
700. " "
705. " "
710. " "
715. " "
720. " "
725. " "
730. " "
735. " "
740. " "
745. " "

No. of feet from surface.

750. Salt, bright crystals.
755. " "
760. " "
765. " "
770. " "
775. " "
780. " "
785. " "
790. " "
795. " "
800. " "
805. " "
810. " "
815. " "
820. " "
825. " "
830. " "
835. " "
840. " "
845. " "
850. " "
855. " "
860. Slightly mixed with shale.
865. Salt, slightly mixed with slate.
870. " " " " "
875. Salt and clay.
880. " "

(The above is published in the form given by the company. It is an exceedingly valuable record, as it clearly shows that the Red Beds extend north to Kanopolis and beyond, whether the geological terms are correctly used or not.)

Little River Well.

Record furnished by the driller, Mr. J. P. Brisben, of Lyons.

No.	MATERIAL.	Thickness.	Depth.
1	Soil	16	....
2	Shale	2	18
3	Red shale	36	54
4	Red sandstone	8	62
5	Red sandstone	9	71
6	Red shale	258	328
7	Blue clay and shale	256	585
8	Salt and shale	10	595
9	Rock salt	70	665
10	Shale	4	669
11	Rock salt	43	712
12	Salt	39	751
13	Shale	8	759
14	Rock salt	35	794
15	Clear salt	54	848
16	Shale	4	852
17	Rock salt	57	909
18	Clear salt	23	932
19	Shale	5	937
20	Rock salt	27	964

Thus we see the eastern margin of the salt bed must be only a short distance west of McPherson.

Sterling Salt Plant.

Sterling Well.

At old sugar works. Record reported by the drillers, Messrs. Palmer & Davis.

No.	MATERIAL.	Thickness.	Depth.
1	Soil and sand	136	136
2	Red shale	348	484
3	Black shale	216	700
4	Salt	10	710
5	Shale	25	735
6	Salt	10	745
7	Salt and shale	12	757
8	Salt and shale	5	762
9	Salt and shale	20	782
10	Salt	28	810
11	Salt and shale	5	815
12	Salt	48	863
13	Salt and shale	6	869
14	Salt	20	889
15	Salt and shale	8	897
16	Salt	68	965
17	Salt and shale	10	975
18	Salt	5	980

Wilson Well.

No.	MATERIAL.	Thickness.	Depth.
1	Black soil, sand, and clay	175	175
2	Sandstone	110	285
3	Blue shale	50	330
4	Red shale	390	720
5	Blue shale	115	835
6	Rock salt	270	1,105
7	Black shale	20	1,125
8	Gypsum	10	1,135
9	Blue shale and gypsum	125	1,260
10	Limestone	25	1,285
11	Slate and gypsum	60	1,345
12	Sandstone and gas	15	1,360
13	Limestone	25	1,385

TECHNOLOGY OF SALT.

BY M. Z. KIRK.

In this short article only a brief discussion of the technology of salt will be given, including the different methods of salt making now in operation in Kansas.

The Solar Process.

There is but one solar salt works in the state, that of the Solomon Solar Salt Company at Solomon City. The brine is obtained from a well about 100 feet deep, although the chief supply enters the well at a depth of only 35 feet. Saturated brine tests 100° on the salometer at 70° Fahrenheit. The brine from the Solomon City well tests from 35° to 40° on the salometer. A few years ago a well was put down to the depth of 1000 feet which produced a brine testing about 60°. The salt plant consists principally of a large reservoir 120 feet square and four long narrow rooms 16 x 300 feet each, known respectively as the "water room," "lime room," "pickle room," and "crystal room." The water is pumped from the well directly into the reservoir, from which by gravity it passes into the other rooms in the order named. The reservoir has no covering on it but each of the other rooms is provided with a portable cover to be kept in place during rains and to be set aside during fair weather. Plate X is a photograph of the plant, showing a part of the reservoir and the four rooms. (See page 77.)

The process of salt making may be briefly described as follows: The brine is pumped from a well by means of a two-and-one-half-inch centrifugal steam pump having a capacity of 600 gallons per minute. It is delivered into a reservoir where it remains considerably concentrated by evaporation. The sediment pumped from the well subsides and is shoveled from the bottom of the reservoir from time to time as occasion requires. To effect such a cleaning the pump is stopped, the brine turned into the other rooms, the sediment shoveled out, and the reservoir properly cleaned with water. The depth of the brine kept in the reservoir is usually less than twelve inches, but considerable variation is noted from day to day, depending upon the rapidity of evaporation and rapidity of pumping.

From the reservoir the brine is first carried into the "water room," where it is rarely allowed to be more than twelve inches deep. Here

the remainder of the mechanically held impurities subside, leaving an entirely clear brine to be passed on to the "lime room." In this second room the evaporation is carried far enough to cause precipitation of the principal impurities held in solution, such as calcium carbonate, calcium sulphate, etc. After sufficient concentration in this room the brine is next conveyed into the "pickle room," or the third one of the smaller rooms. It is left in the "pickle room" until the concentration becomes so great that salt crystals begin forming. It is then transferred into the last or "crystal room," and allowed to remain until concentration causes the precipitation of nearly all the salt.

By the solar process the evaporation is very gradual. The salt crystals begin forming first on the surface of the brine. If the brine is not agitated too much by the wind, the crystals frequently reach a large size; that is, from one-half to three-fourths of an inch on one side of the cube. This is particularly true where some slender object of support, such as a cord, or splinter from the wall of the vat, or a coarse piece of any kind is placed in the brine. Frequently also the well-known hopper-shaped crystals are produced instead of the solid cubes.

After a good bed of salt has been deposited in the "crystal room" it is lifted into large baskets and allowed to drain for a few minutes, after which it is emptied into a horse-car, hauled to the storeroom and allowed to "cure," or thoroughly dry. This coarse salt thus formed is used extensively at the packing-houses for heading in barrels of meat and for salting down hides, but a large part is sold for dry salt after being properly prepared. When thoroughly cured in the "drying room" it is crushed by running it between stone rollers and over a Smith "purifier," and finally through screens made of wire with meshes from 28 to 32 to the inch. This finished product is a fine, dry article, which is placed in bags or boxes and sent upon the market. It is reported that Dr. S. E. Senburn, of Omaha, Neb., uses about four car-loads of this variety of salt each year in the manufacture of medicines.

Lyons Rock Salt Mine.

In August, 1890, Mr. Jesse Ainsworth, the superintendent of the Lyons Rock Salt Company, began the construction of a shaft at Lyons for the production of rock salt. When completed, the shaft was large enough to give two hoisting departments 6x7 feet each, and one ventilating shaft 3x7 feet, inside dimensions.

The drilling in sinking the shaft was principally done by hand, as machine drills could not be used to any advantage.

The method of mining consists essentially of undercutting or channeling from five to six feet back from the face, then blasting the salt down from above. The channeling and drilling machines are operated by compressed air carried into the mine through pipes leading from the engine-room, where the air-compressor is located, as rock salt is tough and difficult to cut. In the earlier days of operating the channeling was done in the shale immediately underlying the salt beds, but this caused considerable dirt to be mixed with the salt, thereby interfering with its sale, and more recently the channeling has been done in the salt itself near the bottom, thereby preventing the admixture of the shale, as the only floor of the mine is now one of pure salt.

The drilling machine is backed to a post which is held in position by end pressure on the floor and roof, produced by set-screws. When the post is once in place a large number of drill holes are made in the salt. Sometimes fifty or more are made at one setting of the post. They are drilled to a distance of from four to six feet in the wall and are charged with dynamite powder and exploded by electricity. In this way more than a hundred tons of salt are broken down at once. The large pieces are then broken up with hammer and pick so that they can be loaded into cars, which in turn are pushed by hand over the tracks to the bottom of the shaft and hoisted in a manner similar to the way coal is hoisted from a large coal-mine. The underground cars at Lyons hold about two tons each.

The salt is hoisted to the upper part of the hoisting house, thrown from the cars into the breakers, which are similar to those used in the anthracite coal-mining districts, and broken into moderately small pieces. From the breakers the salt passes through a series of screens which separate it into nine different sizes or grades. As the salt contains a considerable amount of earthy matter which is difficult to separate, experience has shown that it is best to resort to hand separation for getting rid of such impurities. At Lyons this hand-work is done by a large force of boys and girls, who throw out all the discolored fragments after the salt has passed through the breakers and screens.

Lump Rock Salt.—The largest size of salt marketed is called "lump" rock salt, and is marketed just as it comes from the mine. The lumps weigh from 25 to 200 pounds each, and are used extensively by farmers and ranchmen in Kansas and surrounding states for salt-

Interior of Lyons Rock Salt Mine.

ing stock. The large lumps can be placed in the pasture, feed lots, and barns, so the stock can always have ready access to them.

"C" Fine Salt.—"C" fine salt is the same as above, only it has been reduced to a powder by a crushing process. This is put up in 200-pound burlap sacks and 280-pound barrels for those who prefer the fine salt to the lump. This brand is also sold in large quantities to the ranchmen of Kansas and the Indian territory.

Capping Salt.—Capping salt is the largest size of the crushed material. It is made up of beautiful, clear cubic pieces about three-fourths to seven-eighths of an inch across. To separate out the impurities a large force of boys and girls is employed, who separate the discolored pieces from the pure salt. This carefully collected material is used quite extensively by the various packing companies to place in the bottom and on the top of barrels of pork for export.

No. 3 or Refigerator Salt.—No. 3 or refrigerator salt is in blocks from a fourth to half an inch across. It is especially well adapted for use in a refrigerator car and other refrigerators, as the pieces are large and dissolve so slowly that there is but little waste. About five or six hundred pounds are usually placed in a car at a time with ice. It is used quite extensively, not only in Kansas but also in neighboring states.

No. 2 or Hide Salt.—This brand averages about one-half the size of No. 3. But few pieces measure more than a quarter of an inch in diameter. It is used extensively for salting hides and is much better than the finer grades, because it is not all absorbed or dissolved at once. In case a part of the brine escapes there is plenty of solid salt to produce more.

No. 1.—No. 1 is much finer than the above, the grains being about the size of grains of wheat. This size is well adapted for various purposes. Butchers use it for salting hides, chemical manufactures for making soda ash and caustic soda, packers for making brine, soap makers for making soap, and ice-cream makers prefer it to all other sizes for freezing purposes.

No. 6.—No. 6 ranges from very fine salt dust to pieces as large as grains of wheat. This size is used extensively to remove snow and ice from the rails and frogs of railroad and street-car tracks. Some even prefer this size for salting stock and for curing hides.

No. 7.—No. 7 is much finer than No. 6, the grains being only about one-twentieth of an inch in diameter. Besides being used for curing

sheep pelts and for salting stock, it is used extensively in pickle factories.

No. 4.—No. 4 is about the same as coarse evaporated salt. It is used by stockmen, soap makers, and glass manufacturers. There is a good market for this grade among the smelters of Colorado and other mining states, where it is used in the chlorination furnaces.

PACKERS' FINE SALT.

Packers' fine salt is perhaps the finest, purest and cleanest produced at the mines. It is about as fine as common evaporated salt and is used for general domestic purposes and for packing beef and pork.

These various grades of salt are held in bins occupying the left part of the main building, shown in Plate XI, from which a car can be loaded with any of the above kinds of salt in a very few minutes. The building to the extreme left is the storeroom for the barreled and the sacked salt; the small building immediately in front is the office. The track in the distance and above the storeroom leads from the top of the shaft in the upper part of the building to the dump pile, where the refuse is thrown. Immediately beneath the main building are railroad tracks connecting with the Missouri Pacific, Atchison, Topeka & Santa Fe and St. Louis & San Francisco railroad systems.

The building to the extreme right is the boiler-house, in which are five 250-horse-power boilers.

The next building to the left is the engine-house, in which are two large four-horse-power hoisting engines, supplied with two immense drums, around which is wound the strong steel cable for lifting the cars of salt from the bottom of the shaft. In this building is also the large air-compressor, which compresses the air to a pressure of 100 pounds per square inch. It is then conducted through pipes to the mining machinery described above. North of the engine-house is a higher building, in which are two large 600-horse-power porcupine boilers.

With the above excellent equipment, this mine has a capacity of 1000 tons per day. But they have no occasion at present to run to full capacity. With the present demand, it could easily supply all of the rock salt consumed by the states west of the Mississippi river.

An average of about seventy-five hands are employed during the year. From twenty to twenty-five of these are girls and small boys, employed to sort out the impurities from the salt, at $2 a week. The remainder can be classed as skilled labor, receiving from $1.75 to $3 per day.

Kanopolis Rock Salt Mine.

The Royal Salt Company, located at Kanopolis, as well as the Lyons Rock Salt Company, turns over its products to the Western Rock Salt Company, of St. Louis and Kansas City. Therefore the general remarks on the operation of the Lyons mine are applicable to the Kanopolis mine also.

As seen by Plate XII, this plant is put up much more on the plan of a mill and less like an anthracite coal plant than the one at Lyons. The shaft here is 8x22 feet, and divided into three compartments, two hoisting shafts 6x8 feet and one air shaft 8x10 feet. The thickness of the vein mined here is 10 feet and there is an excellent parting at the top. The underground streets or headings are all 30 feet wide, and the rooms off from them are the same width. The ventilation is most excellent. The air coming down the hoisting shaft divides and runs north and south, then divides again at the extreme ends of the mine and comes around the outer heading and rooms from the east and the west and escapes through the ventilating shaft. In this way there are really four almost separate circuits of air, one in each quarter of the mine. The engine- and boiler-houses, shown in the front of the main building in the plate referred to, were constructed from sandstone used near the present mine in some of the government buildings at old Fort Harker. In the first building are two 300-horse-power first-motion hoisting engines, propelling a large conical-groove drum, around which the cable is wound that hoists the cars, holding about a ton of salt each. In the main building is a large Ingersoll compressed-air machine to supply the power for drilling purposes in the mine. The steam for all this work is produced in the building to the extreme right, where there are four 100-horse-power Brownell & Co.'s boilers.

After the rock salt is hoisted to the top of the main building it is run through a crusher down into a Smith milling separator and those constructed by the superintendent, James Cowie. With this excellent equipment the company is able to supply large quantities of all varieties of rock salt.

Kingman Rock Salt Mines.

The salt-mining industry was very much overdone at the beginning of the business in Kansas. The two mines at Kingman apparently did a thriving business for a few months, but they have long since been abandoned. The shaft that was put down in the western part

The Kanopolis Rock Salt Plant.

of Lyons was abandoned before it was completed. A prospect hole was put in and preparations were made to sink a shaft at Little River, but work has not yet been commenced. The mines at Kanopolis and Lyons are now under the same management, and are being run in the most economical way, and will probably be able to fill the entire demand for rock salt for a number of years.

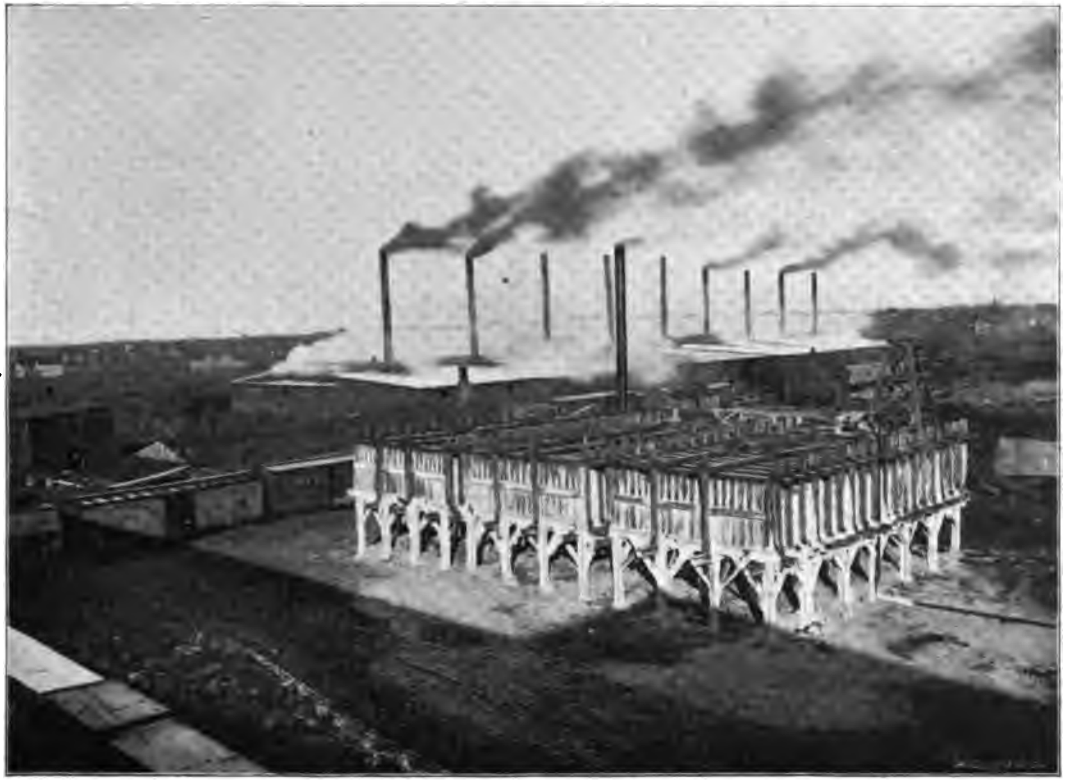
Evaporated Salt.

WELLS.

Only a small per cent. of the salt used in the United States is taken from the mine, but water is forced through wells and allowed to become saturated, and then brought to the surface and evaporated.

The most of the wells in Kansas are made in the following way: With a large derrick and an eight- or ten-horse-power engine an eight-inch hole is put down below all veins of fresh water, which in the Arkansas valley is from 150 to 200 feet; an eight-inch casing is driven into this hole to shut off the flow of water. Inside of this is let down a five-and-five-eighths-inch pipe, and again drilling is begun with a five-and-one-half-inch bit, and the hole drilled to the bottom of the salt, or nearly so; the pipe is then driven down to the top of the salt, or a little below, and allowed to extend to the top of the well; inside of this is placed a two-and-one-half-inch pipe, so it will reach within ten or fifteen feet of the bottom of the well; an elbow is screwed on the top of the five-and-five-eighths-inch pipe, with a hole in it for the small pipe, and joined so there will be no leakage. The small pipe is attached to a steam-pump. The water is lifted from a large fresh-water well and forced down the small pipe into the salt bed and dissolves the salt. The pressure applied from the pumps is so great that this brine is forced to the surface through the five-and-five-eighths-inch pipe.

When a new well is opened it is best to give it time, for the water will dissolve out the salt near the bottom. When properly started one well will supply enough brine to make several hundred barrels of salt per day. However, it sometimes happens that the rock and shale left without support as the salt dissolves will fall in and break off the pipe and destroy the well. It is difficult to estimate the number of cubic feet of rock salt beneath a given area of land and from that estimate the number of barrels of salt that could be made from it, for the conditions are so varied such a calculation would necessarily be entirely



Hutchison Salt Plant—General View.

general rather than specific. It might, however, be stated that some of the best wells have been in operation for years and apparently the salt has been dissolved from beneath only a few square rods.

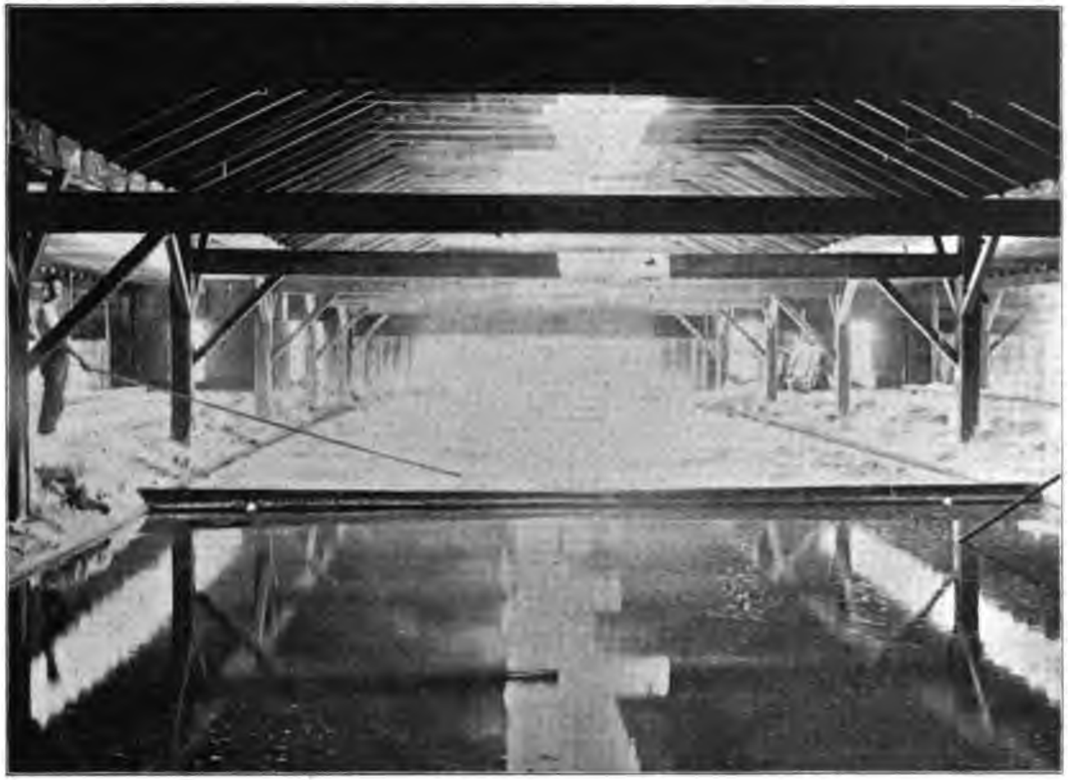
Evaporators.

After the brine is pumped from the well it is deposited in large brine tanks at the several factories, shown in the foreground of Plate XIII. By referring to the cuts of the various salt plants, it will be seen that the brine tanks are always quite prominent. Here it is stored ready for use. While standing here the various impurities are given an opportunity to settle. It will be noticed on the above cuts that these tanks are always built high enough for the brine to run to the sheds and into the pan by force of gravity. From Plate XIII we get a general idea of the exterior appearance of a salt plant. We see the buildings are broken up into bents or sheds, which have long ventilators at the top and a smoke-stack at one end. Each of these bents or sheds covers an evaporating-pan where the heat drives the water off and the salt is deposited. The long shed with a single sloping roof placed at the smoke-stack end of the bent is the "store-room," "curing room," or "runway," where the salt is deposited to cure and dry, and is later barreled and shipped. We also see near the main building at most of the factories a small boiler-house where steam is made for running the pumps and propelling the machinery Usually also there is a cooper shop near by where barrels are set up and prepared for use.

Now let us step into some of these salt plants or blocks and see how the salt is made. However, we must first understand that there are three principal methods of producing salt, viz.: The pan process, the grainer process, and the vacuum process. These are all quite simple in theory, but the plants are so large that the equipment may seem somewhat complicated.

THE PAN PROCESS.

This process is the evaporation of brine by direct heat. The plant is built on very much the same principle as the common country sorghum factory. As we step into the pan room we see a long, wide pan, as shown in Plate XVII. They are frequently arranged in series, as shown in Plate XVIII. In order to get a clear idea of the ground plan and elevations of such a plant, let us turn to the drawings given in Plate XVI, fig. 1. *A* and *B* represents the full length of the pan, which is 24 or 25 feet wide and from 85 to 115 feet long. This is



Interior of a Hutchinson Salt Plant, Showing Evaporating Pans (end view).

Interior of a Hutchinson Salt Plant, Showing Evaporating Pans (side view).

all one pan, with just a thin partition dividing *A* from *B*, so the cold brine enters *A* and warms up and then flows over this small partition into the main pan where the salt is deposited. This pan is made of large plates of three-eighths-inch steel, and very carefully riveted and calked. The pans are usually about one foot in depth, as shown by *a* and *b*. It is supported in this position by brick pillars about three feet square, placed twelve feet apart, as at *I*, and by the arches *K*, shown in the front end of the fireplace. An end elevation view shows us the size of the stone and brick wall *L*, and the shape of the fire-brick arches *K*, and the position of the grates *D*. Each pan, therefore, is heated by three great furnaces. The pan *F* is a little flared at the side and provided with a slightly slanting "drip board" *G* running the entire length of the pan and just a little above the floor *H*. To prevent the pan from burning, an archway is built just above the furnace for several feet back, as represented at *C*. This is not solid throughout its whole length, but left partly open, so the heat can get through just enough to keep this portion of the pan about the same temperature as the parts farther back.

Returning to Plate XVII, we can see very clearly in here the shed and the pan in the foreground, which is the small pan where the brine first enters from the tank. When it flows over the division it begins to deposit salt as soon as enough water has been driven off by evaporation. The brine is kept at a temperature of 175 to 200 degrees F. On a damp, cold day the steam condenses very rapidly in the rooms, and one can see only a few feet away. On a bright, warm, slightly windy day the vapor is borne away, and one can frequently see from one end of the shed to the other.

As great volumes of steam are constantly being driven off, the workmen, or "rakers" as they are called, perspire profusely. Except in the coldest weather, they generally wear nothing but shoes and pants, and in many cases the former are omitted and the latter very much shortened.

The salt rakers in charge usually allow the brine to evaporate about two hours undisturbed. During this process one can see thin layers of salt crystals constantly forming on the quiet surface of the brine, and as they increase in size and number the thin film breaks and the minute cubic crystals fall to the bottom. When this process has continued long enough the rakers take their long-handled "skippers," which are merely long, heavy hoes, the steel part being about six by eighteen inches, hinged so that the blade can move towards the holder,

When it is pushed back towards the middle of the pan the blade drops up against the handle and skips along over the brine. The men arrange themselves on either side of the pan and rake the salt from the middle out upon the drip boards, where it remains for an hour or more to drain and dry.

When the salt is all removed from the pan the rakers run their skippers over the bottom to feel for "scales." This scale is largely a deposit of gypsum (calcium sulphate), mingled with other impurities. When the pan becomes very hot the scale collects on the bottom badly. It often collects to a thickness of two or three inches, or even more, unless very carefully watched. As it is a poor conductor of heat, the pan is unable to transmit the heat to the brine and the heavy sheets of steel soon become red hot and buckle badly. As it is a great expense to let a pan cool off and then heat it up again, the rakers arrange a platform or bench over the hot brine, and with a heavy crowbar pound the scale until it cracks loose. When the steam bursts it loose it not infrequently throws hot brine high into the air, making the workman's position a dangerous one. If the scale cannot be loosened by this method a crowbar is run under it and it is pried loose and carried to the waste pile.

When a pan becomes badly buckled they are compelled to put out the fire and let it cool off for repairs. While the men are scaling the pan the salt which we have left on the drip board has had an opportunity to become fairly well dried. It is then shoveled into carts holding about a ton and wheeled into the great storeroom, called the "runway," as shown in Plate XIX, and pushed down the walk, where the salt is dumped to the floor some ten or twelve feet below. They continue to dump the salt here until all the space below is filled and it is piled up a foot or more above the walk. When the runway is full and the salt nicely piled up it presents the beautiful appearance shown in the plate.

It remains in the runway from twenty to sixty days to dry out and cure, during which time the pile settles several inches, and where there has been a large amount of moisture the salt becomes quite lumpy and solid. A stroke, however, with a pick or shovel, breaks the lump into fine salt. Plate XX represents the packing room, which is a view taken from below Plate XIX. The salt is shoveled in barrels and pounded down to allow the required 280 pounds per barrel. The barrel nailer then puts in the heads, nails down the hoops, puts on the proper brand, and at last the salt is ready to be loaded into the cars for

Runways in a Hutchinson Salt Plant.

Packing-room in a Hutchinson Salt Plant.

shipment. Salt shipped to the packing-houses is emptied into the cars loose instead of being barreled.

By referring to table XXIV, it will be seen that the greater part of the salt produced in this state is made by the pan process. The two largest companies in the state, the Hutchinson, and the Kansas Salt Companies, use this method exclusively.

Cooper Shop.—A cooper shop is usually connected with each plant. The hoops and headings are bought already prepared. Some of the staves are bought all ready tampered while others are plain. Salt barrels are made from the cheapest material, as elm, pine, and other cheap lumber. The most of the barrels used in this state are eighteen and one-half inches in diameter, and the staves twenty-nine or thirty inches in length. With good material and tampered staves, one man can set up sixty or eighty barrels in a day, for which he receives from two and one-half to three cents each.

THE GRAINER PROCESS.

The grainer process is truly an American system. The weak brines existing in Ohio and the Kanawha region demanded some cheaper method of producing salt from them than the old kettle and pan process. When salt was found in the great lumber region of Michigan, the operators of the lumber industry soon saw how easily they could profitably combine the lumber and salt industries. Wells were sunk and salt plants erected near the sawmills, and the exhaust steam was conducted through the pans of brine during the day, and when the mill was stopped at night direct steam was used. When the brines are low grade, and where exhaust steam can be used, this process may be superior to any other. In Kansas, where we have fully saturated brine, and the steam is produced solely for the manufacture of salt, it is a much vexed question as to which is the more economical—the pan or the grainer process. The operators of each system seem to be fully convinced of the superiority of their methods, and can point out numerous difficulties and expenses in the other.

The Barton Salt Company put in the first grainer in the state, in the old packing-house at Hutchinson. As this is the largest grainer plant in the state, and a typical one, it will be described in detail.

In Plate XXI, fig. 1 represents a section of the plant in operation; fig. 2, an end elevation of the pan; fig. 3, a cross-section of the pan; fig. 4, a view of the pan from above; while figs. 5 and 6 represent another pan and grainer process. In figs. 2 and 3, *E*, *F* and *G* are the

timbers supporting the large wooden pan; H is the floor, made of the best 3-inch cedar lumber; K is a heavy crosspiece holding the sides of the pans together and supporting the drip board L; N is the pipe from the brine tank; I shows the boards forming the end of the pan. In fig. 3, E represents the position the steam-pipes are held in by the small iron rods fastened to K.

Figure 4 is a grainer pan 130 feet long by 12 feet wide. The steam from the boiler enters the pipes P at the middle of the right-hand end of the pan and divides, a part going through the four pipes shown on the right-hand side of the pan, and the remainder passing through the four pipes on the left side, and then through some small pipes back to the boiler. Thus the water is evaporated from the brine and the salt deposited. With some crooked-handle hoes the men rake the salt to the sides of the pan, then with shovels lift it onto the table or drip board Q where it is quite thoroughly dried before being hauled to the runway.

Figure 1 represents an outline of an entire plant in operation. At the left we see the large brine tank which is always outside the building, as can be seen from the various half-tone plates. The brine is deposited here from the well the same as in the pan process. In the early history of the salt business in Kansas the brine was drawn from this tank into the settler, where it was heated to boiling and the water driven off until salt began depositing. In this way a large part of the scale was deposited in the bottom of the settler on the steam-pipe. This system was continued for some time, but owing to the abundance and purity of strong brine it has been abandoned. Now the brine is nearly heated in the settler before being drawn off through the pipe M into the various pans. In the Barton plant there are eight pans, but as they are all alike only four were shown in this cut.

The steam used in evaporation is supplied by three sixteen-foot boilers, two of which are sixty-six inches in diameter and one sixty inches. The ten-inch pipe V conducting the steam from the boiler is connected with smaller pipes U leading to the grainers, and regulated by a valve in each, and is itself reduced as it recedes from the boiler. After the steam has made its complete round through the pan it is returned to the boiler through the return pipes R shown at the end of each pan. Formerly the return pipes were above the pan instead of below, but it was found to be much more economical to have the return pipes lower than the pan.

When the brine is fresh and the steam-pipes are all clean salt can

be made very rapidly by this process. In order to assist in getting the thin layer of salt on the surface of the brine to break and fall to the bottom more rapidly they often add a little oil to the brine. In the Barton plant about two pounds of the best butter is used each day in the light pan. It is best to keep the brine as quiet as possible, and at a temperature of about 180 or 190 degrees F.; so the salt is lifted (or removed) only about six or seven times in a day of twenty-four hours.

In warmest of weather the steam is shut off while the men lift the salt and throw it upon the drip board to dry. When it has dripped a sufficient length of time they push out a bridge from the door of the runway to the end of a drip board and run out a cart to haul away the salt. After it reaches the runway the remainder of the treatment is very much the same as that already described for the pan process. In cold weather the condensed steam in the pan room is so dense that the workmen can see only a few inches from their faces. Under such circumstances they are constantly in great danger of stepping off into the hot brine while removing the salt from the drip board. Such accidents, although very seldom, do occasionally happen.

As the process is a continuous one, with new brine constantly added and salt continuouly deposited, certain very soluble impurities are not thrown down, and therefore the brine gradually becomes more nearly saturated with them. This makes it necessary to drain off this old brine or "mother liquor" every week or ten days. The less soluble impurities, especially gypsum, collect on the hottest parts of the steam-pipes, coating them with a scale which is a poor conductor of heat and which thus retards the evaporation. After the brine is drawn off and the pipes still dry a good head of steam is turned into the pipes, which causes them to expand and loosens the scale so it can be removed. Salt of the finest grain is produced when the pipes are clean and the evaporation the most rapid.

Grainers similar to the one just described are used in the following plants: The Sterling plant, at Sterling, the Queen City and Barton plants, at Hutchinson, and the Jarvis and Crystal plants, at Kingman.

The Reno salt plant, at Hutchinson, is a combination of the pan and grainer processes. The fire-box is arranged in such a way that the heat produces steam in a boiler, and the smoke and heat from the furnace pass beneath the pan in the same way as in the pan process. The steam is then piped through the pan in the same way as in the ordinary grainer process.

The Star Salt Plant.

Figures 5 and 6 of Plate XXI represent another plan for the grainer process which has been in use for several years at the Star salt plant at Hutchinson. From figure 5 we see that the pan is very similar in shape to those used in the pan process, only this one is but twelve feet wide and twenty-three inches deep, the sides being slightly flared and connected with the drip boards *W*. The two pans used here are made of two-inch lumber and lined with one-inch.

As seen in figure 6, Plate XXI, the steam-pipes lie across the pan instead of lengthwise. They are placed twenty-two inches apart and six or eight inches from the bottom of the pan. When the salt is deposited it can be raked with a skipper and hoe in a way similar to that described in the pan process. This method eliminates the necessity of working immediately above and in the steam from the pan, or of going out over the boiling brine to scale the pan, as with the other system.

As one end of the pan is three inches lower than the other, it may be drained at pleasure and the pipes and pan cleaned.

This method is in use at the Union Ice and Salt Company's plant at Hutchinson, where they have four pans sixty feet by twelve feet by twenty-three inches. The manufacture of ice is their chief business, but all the surplus steam from the plant is conducted into these four grainers. Their boilers furnish enough steam to keep all four grainers in operation during the season when the ice business is light, while at other seasons only three, two, or even one will be kept running continously. All four of the pans are usually filled with brine, but, of course, the one receiving the smallest amount of steam evaporates very slowly and thus forms the largest crystals. They always have a ready sale for all of their coarse salt for capping purposes at the packing-houses.

VACUUM PROCESS.

The vacuum process was first introduced into Kansas in the fall of 1895 by the Hutchinson Packing Company. As this is an entirely new system in the state, and we have no cuts to illustrate the process, but little will be said upon this subject. In this system there are three distinct compartments, all combined, forming somewhat the appearance of a jug. At the bottom and in the central part is the fire-box; next to this is the brine compartment; and a third or outside space conducts away the smoke. The inner and outer divisions are connected by pipes, which run through the brine and give off the heat

The Hutchinson Packing Company's Salt Plant.

for evaporation. A vacuum pump is attached to the top of that portion containing the brine. This removes a large portion of the air and pressure, allowing evaporation to take place at a much lower temperature. The salt forms and falls to the bottom, and is carried to the top of a high bin by an automatic elevator. Fresh brine is supplied through this elevator as rapidly as evaporation takes place. By this system a great saving is made in labor, in not having to rake the salt and shovel it into carts, and a very fine-grained salt is produced.

MANUFACTURE OF DAIRY SALT.

The three great points sought in producing dairy salt are purity, fineness, and dryness. In order to get the purity the operator usually takes the first few drips after the pan or drainer has been thoroughly cleaned. It is also desirable that the salt shall be deposited in as fine crystals as possible, and for this reason the brine is subjected to a high heat. This not only makes the crystals small, but the impurities are attracted to the unusually hot pipes or pans. In the grainer process a little butter aids in making the film of salt crystals break and fall to the bottom while they are yet very small. In the pan process a little resin serves the same purpose. The vacuum process produces an exceedingly fine-grained salt with but little extra effort. The Solomon Solar Company and the Hutchinson Salt Company grind their best product in stone buhrs.

In all cases, even the originally fine product or the ground product, it is run through a large iron or wooden cylinder about fifteen feet in length by five or six feet in diameter, to be specially dried. At the Solomon Solar Salt Company plant, this cylinder is made of iron, and fits quite closely over a large brick furnace. The salt running through this revolving cylinder becomes heated and very thoroughly dried. Where the revolving cylinder is made of wood, as at the Hutchinson Packing Company's plant, and the Kansas and the Hutchinson Salt Companies' plants, the heat is supplied from a large steam drum, or a series of pipes within. When the dry salt comes out it is run through bolts similar to the bolts of a flour-mill. It is then ready to be packed in boxes or bags and delivered to the trade.

The following brands of table and dairy salt are familiar to the ordinary groceryman: The Solar table salt, the Sunflower brand, the Seal table salt, and the R. S. V. P.

Chemistry of Salt and Brine.

From the analysis given later, we can see that the chemistry of Kansas brines is very simple. There is but one valuable constituent, viz., common salt, and the only especially objectionable ingredient is calcium sulphate, or gypsum. The chief aim of the salt manufacturer is to remove the gypsum and other impurities as completely as possible, and to get a deposit of pure salt with the least possible expense.

Common salt, NaCl, Halite, crystallizes in the regular system, usually in cubes, rarely in octohedrons. The faces of large crystals are often cavernous or hopper shaped. This is especially noticeable in crystals from solar evaporation, or where a small amount of exhaust steam has been used in producing the salt. The cleavage along the cubic faces is perfect. It has a hardness of 2.5 and a gravity of 2.1 to 2 and 2.256; in pure crystals, 2.135. The purest crystals of rock salt are colorless, while the evaporated salt is white, but owing to impurities it sometimes has a reddish, yellowish, bluish or purplish hue.

The chemical composition is NaCl—chlorine 60.7, sodium 39.3. But it is often mixed with some sulphate of lime, chloride of calcium, chloride of magnesium, and sometimes with sulphate of magnesium. These impurities attract water from the atmosphere, causing the salt to "sweat" and cake, and hence are very objectionable.

When salt is heated in a closed tube it fuses, often with decrepitation. A deep yellow flame is produced when fused on a platinum wire.

According to Poggiale, 100 parts of pure water at sixty degrees Fahrenheit will dissolve 35.9 parts of salt; so a fully saturated solution contains 26.46 per cent. salt and has a specific gravity of 1.2055. In practical work differences will always be observed, for the various impurities in the brine will produce some changes in its salt contents when fully saturated. The presence of lime and magnesium salts, even in small quantities, will increase the reading on the salometer. The amount of the above impurities in the Kansas brine is so small that the salometer seldom reads more than 100 or 102, and this variation is very often due to inaccurate salometers or to a low temperature. The lower the temperature the greater the density to a certain degree, and the higher the temperature the more the liquid will expand, and of course the density is decreased.

THE IMPURITIES OF BRINE.

It has been seen in the various processes of manufacture that the most troublesome impurity has been the gypsum. When it crystallizes from a solution in water or brine it forms the ordinary gypsum. This is a hydrous sulphate of lime and contains twenty-one per cent. of water, though sometimes it forms with only one-half as much water as the above.[1] If this gypsum is deposited on the bottom of the pan or on the grainer pipes when the water is at or near the boiling-point it approaches the anhydrous state. It then contains little water of crystallization and becomes more perfectly anhydrous as it lies on the hot pan or pipe for some time.[2]

Marignac[1] gives the following table, showing the solubility of gypsum and anhydrous sulphate of lime in pure water at different temperatures:

Temperature.		One part of gypsum dissolves in —	One part of anhydrous sulphate of lime dissolves in —
32.0° F.	0° C......	415 parts of water..	525 parts of water.
64.5° F.	18° C......	386 " " ..	488 " "
75.2° F.	24° C......	378 " " ..	479 " "
89.6° F.	32° C......	371 " " ..	470 " "
100.0° F.	38° C......	368 " " ..	466 " "
105.8° F.	41° C......	370 " " ..	468 " "
127.4° F.	53° C......	375 " " ..	474 " "
161.6° F.	72° C......	391 " " ..	495 " "
168.8° F.	86° C......	417 " " ..	528 " "
212.0° F.	100° C......	452 " " ..	672 " "

The above results show that the sulphate of lime is most soluble at 100° F., being less soluble both above and below that point. He further found that solutions of sulphate of lime have a great tendency to supersaturation; that is, when a solution was evaporated at ordinary temperature, 0.618 per cent. of sulphate of lime was found, while, according to the table, at 75° F., it should be only about 0.21 per cent. A solution saturated at the ordinary temperature contained 0.438 per cent. and began to form a deposit at the end of twelve hours. This gradually increased, so that at the end of twenty days there remained but 0.18 per cent. in solution. But when a portion of the original solution was raised to the boiling point an abundant deposit resulted,

1 H. Rose: Poggendorff's Annalen, vol. 93, p. 606.

2 See Salt-making Process, Seventh Annual Report Director U. S. Geological Survey, pp. 491-535.

1 Annales de Chimie, Paris, 5th series, vol. 1, p. 274.

and after boiling a few minutes the solution contained but 0.218 per cent., having thus deposited at once two-thirds of the sulphate present.

It is therefore readily apparent why a boiling heat is desirable for the rapid precipitation of the sulphate of lime, as was used for a time at the Barton salt plant, but which was finally considered unnecessary on account of the high degree of purity of our brines, and was finally abandoned.

Goessmann[1] has shown that the presence of chloride of sodium in the brine decreases the amount of the sulphate of lime dissolved, which always becomes less as evaporation progresses, as is illustrated by the following table:

MATTER.	Original of lime, sp. gr. 1.1225 = 65 salometer at 70° F.	Pickle, sp. gr. 1.2062 = 100 salometer at 70° F.
Sulphate of lime	0.5772	0.4110
Chloride of calcium	0.1533	0.2487
Chloride of magnesium	0.1444	0.2343
Bromide of magnesium	0.0024	0.0039
Carbonate of protoxide of iron	0.0044	....
Chloride of sodium	15.5317	25.7339
Water	83.3774	73.3488
Totals	100.	100.

1 Charles A. Goessmann: Report on the Manufacture of Solar Salt, etc., 1864, p. 6.

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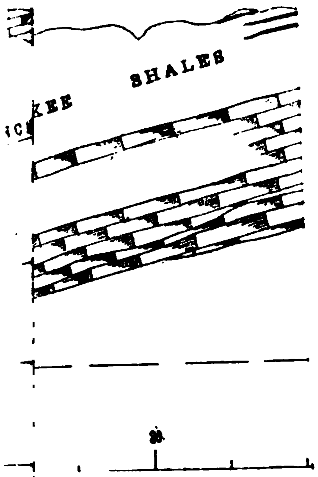
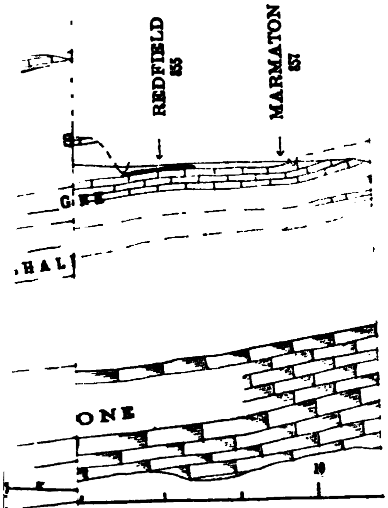
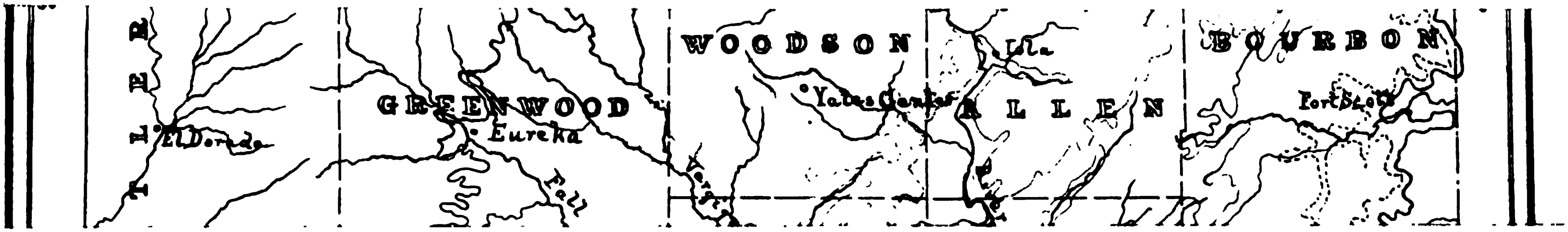
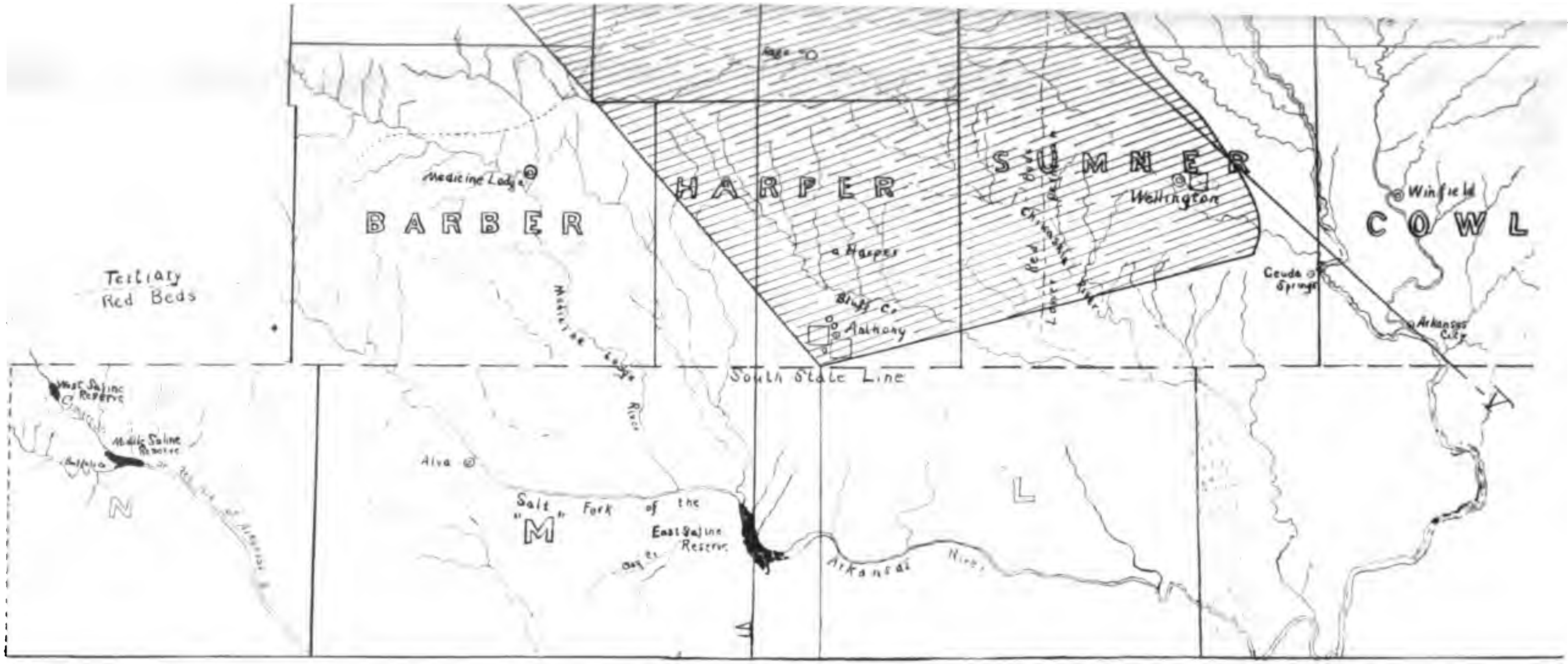


Annual Bullet



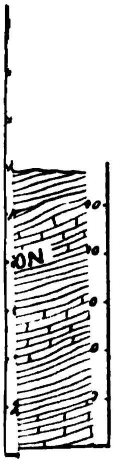

WOODSON
BOURBON
GREENWOOD
ALLEN
Iola
Yates Center
Fort Scott
El Dorado
Eureka
Fall
Verdi

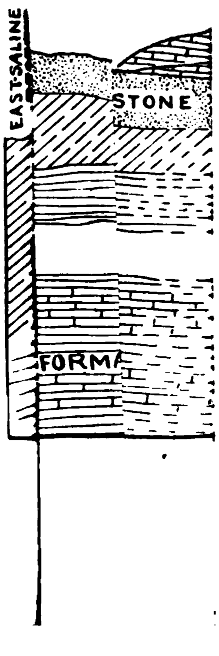


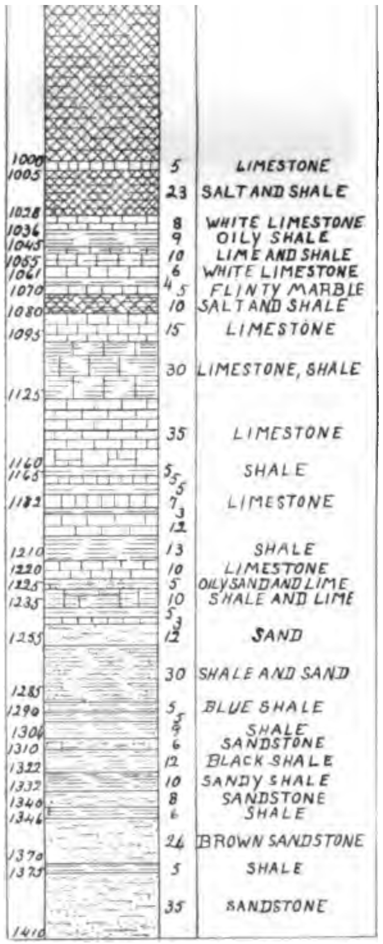
MAP OF MIDDLE KANSAS, SHOWING SALT AREA.

Dark shaded area, Salt Marshes. Light shaded area, Rock Salt.

198. P



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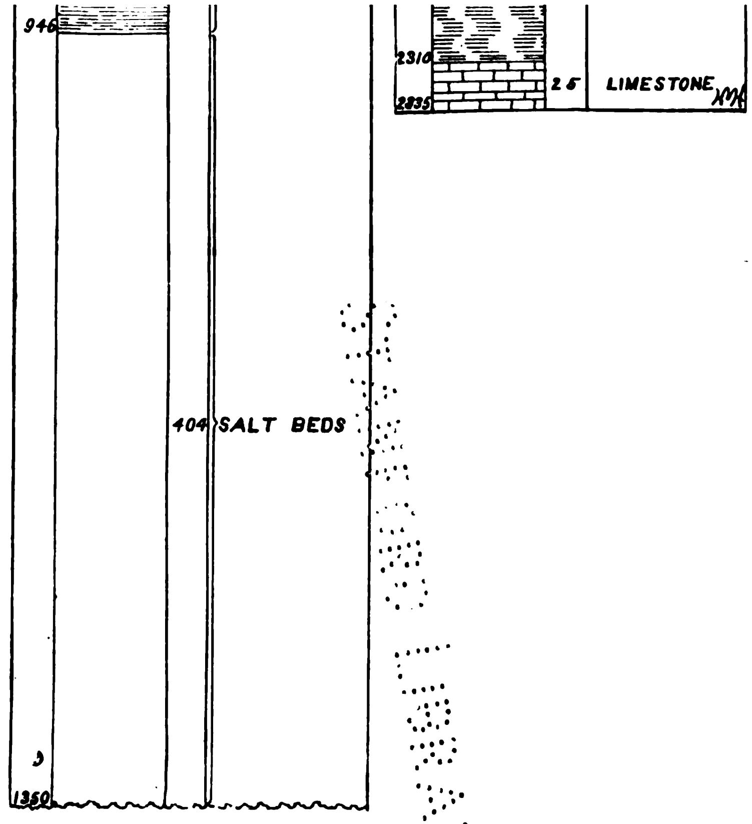
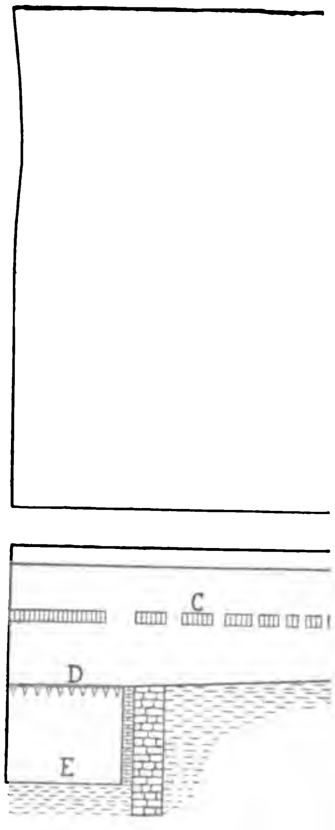
1322
1332
1340
1346
1370
1375
1410
5 LIMESTONE
23 SALT AND SHALE
8 WHITE LIMESTONE
9 OILY SHALE
10 LIME AND SHALE
6 WHITE LIMESTONE
4 5 FLINTY MARBLE
10 SALT AND SHALE
15 LIMESTONE
30 LIMESTONE, SHALE
35 LIMESTONE
5 5 5 SHALE
7 3 12 LIMESTONE
13 SHALE
10 LIMESTONE
5 OILY SAND AND LIME
10 SHALE AND LIME
5 3 12 SAND
30 SHALE AND SAND
5 5 BLUE SHALE
SHALE
6 SANDSTONE
12 BLACK SHALE
10 SANDY SHALE
8 SANDSTONE
6 SHALE
24 BROWN SANDSTONE
5 SHALE
35 SANDSTONE


946
404 SALT BEDS
1350
2310
2835
25 LIMESTONE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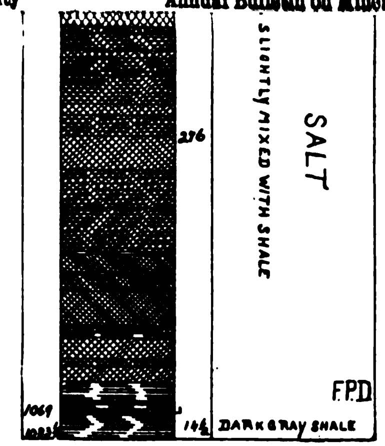
SALT
SLIGHTLY MIXED WITH SHALE
276
F.P.D.
14½
DARK GRAY SHALE
1069

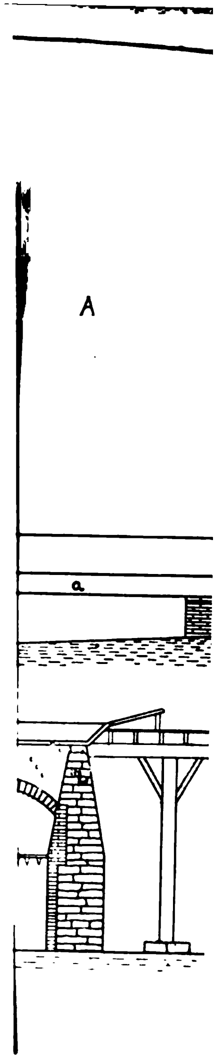
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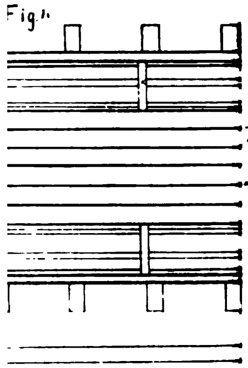
Fig.



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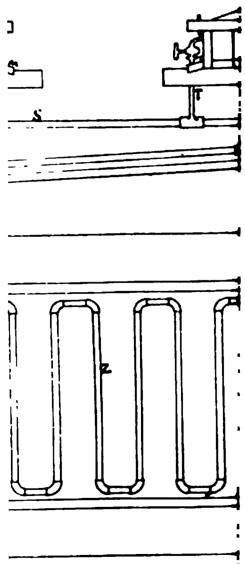

ALT PLANT AT

Mineral Resources of Kansas.

1899.

Gold and Silver.
Lead and Zinc.
Coal.
Oil and Gas.
Gypsum
and Gypsum Cement Plasters.
Building and Other Stone.
Clay Products.
Hydraulic Cement.
Salt.

THE

UNIVERSITY GEOLOGICAL SURVEY

OF KANSAS.

CONDUCTED UNDER AUTHORITY OF THE BOARD OF REGENTS OF THE UNIVERSITY OF KANSAS, AS AUTHORIZED BY SPECIAL LEGISLATION.

ANNUAL BULLETIN

ON THE

MINERAL RESOURCES

OF KANSAS,

1899.

INCLUDING A REPORT UPON GOLD AND SILVER, LEAD AND ZINC, COAL, OIL, GAS, GYPSUM, BUILDING STONE, CLAY PRODUCTS, HYDRAULIC CEMENT, AND SALT.

BY ERASMUS HAWORTH,

Department of Physical Geology and Mineralogy, University of Kansas.

LAWRENCE, KANSAS:
MAY 1900.

The Geological Survey publications are distributed from the University, at Lawrence.

MEMBERS OF THE UNIVERSITY GEOLOGICAL SURVEY OF KANSAS.

F. H. SNOW,
Chancellor of the University and *ex officio* Director.

ERASMUS HAWORTH,
Department of Physical Geology and Mineralogy.

S. W. WILLISTON,
Department of Paleontology.

E. H. S. BAILEY,
Department of Chemistry.

FOR ANNUAL BULLETIN ON MINERAL RESOURCES OF KANSAS FOR 1899,
ERASMUS HAWORTH, Geologist.

LETTER OF TRANSMITTAL.

Dr. F. H. Snow, Chancellor of the University of Kansas:

DEAR SIR — I have the honor to submit to you herewith my annual report on the mineral resources of Kansas for the year 1899, which will constitute the third annual bulletin of this series. It affords me great pleasure to state that the mining and metallurgical interests of Kansas during the past year were by far the most prosperous of any year in the history of the state.

Yours most respectfully,

ERASMUS HAWORTH.

DEPARTMENT OF PHYSICAL GEOLOGY AND MINERALOGY,
UNIVERSITY OF KANSAS, May 30, 1900.

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INTRODUCTION.

DURING the year 1899 all mining and metallurgical enterprises within the state of Kansas were unusually prosperous. The operations of the Argentine Smelting and Refining Company were much more extensive than ever before in the history of the refinery, aggregating more than $20,000,000, and raising the total value of the business done by this company since its organization to the magnificent sum of more than $147,000,000. Their marketable products during the year were refined gold, refined silver, blue vitriol or copper sulphate, white vitriol or zinc sulphate, and metallic lead.

The lead and zinc mines at Galena felt the influence of the unusually high prices of zinc ores during the greater part of the year. This resulted in unusual activity, particularly in the building of new concentrating mills for handling the ore after it was raised from the ground. The aggregate value of the lead and zinc ores at the mine reached the unprecedented sum of considerably more than $2,500,000, while the value of the preceding year of 1898 was less than $2,250,000. The actual amount of ore produced, however, was smaller than the output for 1898. The total tonnage of zinc ores in 1899 was 63,369.21, while for 1898 it was 74,852.35, according to figures gathered by Mr. Russell Elliott, of Galena, for that year. The tonnage output of lead ore produced for 1899 was likewise below that of 1898. For 1899 it reached a total tonnage of 6,595.19, while for 1898 the tonnage was 7,918.28. This decrease in the actual amount of ore produced is a great surprise to most observers who witnessed the unusual activity in mill building and the purchase of mining property by Eastern companies during the year 1899.

The unusually high price of ore maintained throughout the

year brought the total value to the figures above given. The average price of zinc ore was about $38.50 for 1899, while the average for 1898 was a little over $26.50, and the highest for any previous year in the history of zinc mining at Galena—that of 1897—was a little in excess of $25 per ton. The unusually high price of ore was dependent upon the correspondingly high price of spelter in New York and London, which reached the unprecedented average of $5.75 for the year in New York. The highest price known before in New York city since 1892 was that of 1898, which averaged throughout the year $4.57. The price of lead ore, however, was a little higher than for 1898, as it averaged $26.31 per 1000 pounds, the unit of measurement, while for 1898 the average was a little over $21.

The output of zinc smelters located on Kansas soil was much greater than ever produced before in the history of the state, reaching the magnificent sum of 55,872.2 tons, as against 38,543 tons for 1898, which in turn was the largest production in the history of the state. This excessively large output of metallic zinc, in connection with the high price of spelter, lifted the total value of metallic zinc produced, reckoned at the New York market price, to nearly six and one-half millions of dollars—almost double the value of the smelting products of any other year in the history of the state. This excessive increase in the tonnage of metallic zinc produced is dependent principally upon the large number of smelters operated in the natural-gas belt of Kansas. The greater number of the coal furnaces in the vicinity of Weir City and Pittsburg were likewise in operation during a considerable part of the year, and for the first time more than one-half of the total spelter production came from the gas furnaces.

The coal mining industry of the state was much greater, both in tonnage of coal produced and in the value of the same, than ever before known. The total tonnage for the year reached beyond the four million line, about 200,000 tons more than was produced in 1898, which in turn was over 200,000 tons greater than ever before produced. The price of coal, also, was higher than it had been for a number of years, the

average for the state at the mine being $1.25 per ton, making the total value of the coal production considerably over $5,000,000, or about twenty per cent. greater than ever before known.

The production of oil was about the same as in 1898, while the natural gas consumed was much greater than in previous years, due principally to the operation of the large zinc smelters which use gas for fuel.

The gypsum and gypsum cement plaster industry manifested great activity throughout the year, producing a total of over 60,000 tons of marketable material, the largest ever reported for the state excepting for the two years of 1894 and 1895. One noticeable feature of the industry is that the Acme Cement Company operated no furnaces in the state during the year, thereby removing from the state a company whose operations in previous years had been an important factor in the total production of gypsum cement plaster. The price per ton for the manufactured product as reported by the different companies averaged $4.30 at the factory, a considerable increase over that reported for 1898. The aggregate value of the total product this year was a little over $290,000, the highest total value reported for any one year, excepting that of 1894.

The stone quarrying industry was very active during 1899, particularly in the way of ballasting railroads with crushed stone and building new abutments and culverts by the different railroad companies. It is estimated that the value of crushed stone used for ballast alone reached fully $300,000, while the total value of dimension stone used in various kinds of building operations was nearly as great, making the value of the stone product greater, perhaps, than ever before known.

The various clay industries were most active and produced larger quantities of goods than ever before known in the history of the state. The tendency is for very large factories to produce the various grades of brick and tile and ship them to the points of consumption. This is particularly so in the natural-gas fields, where gas is used so advantageously for fuel. The total value of the clay products aggregates $400,000.

The hydraulic cement industry in Kansas is not what it

should be. The two factories at Fort Scott are the only ones in operation in the state, while the great abundance of material suitable for making a high grade of hydraulic cement would warrant the erection of other plants, provided there is a market demand for this variety of cement. The production for 1899 is about the same or a little less than for 1898, reaching only 140,000 barrels.

It is interesting to report that an exceedingly large factory for the production of Portland cement is under process of construction at Iola, where natural gas will be used for fuel. This plant, it is estimated, will be ready for operation some time during the year 1900, and, when once completed, will have a capacity of from 2000 to 3000 barrels per day. It is probable that other places would afford the necessary material for the manufacture of a high grade of Portland cement, and, so long as this material is imported to America so extensively, it would seem that this industry is one of the most desirable.

The output of the various salt mines and salt plants during 1899 was exceedingly large, reaching considerably more than 2,000,000 barrels. The price of salt was better than for a number of years, averaging about thirty-five cents per barrel at the factory, making a total value of the salt at the factory of over $760,000. If to this be added the value of the cooperage used in marketing the salt, we have a total output for the industry of considerably over $1,000,000, being much larger than ever before in the state.

No new industry that would properly belong to the division of mines and minerals has been inaugurated, excepting the Portland cement industry above mentioned.

TABLE I.

SHOWING VALUE OF EACH OF THE MINERAL PRODUCTS OF KANSAS FOR 1899, AND SINCE INDUSTRY BEGAN.

Name of Product.	Amount for 1899.	Value per unit.	Value for 1899.	Grand total of production since industry began.
NON-METALLIC PRODUCTS.				
Coal . . . . . tons	4,096,895	$1 25	$5,124,248 00	$60,209,889 41
Coke	. . . . .	. . . . .	250,000 00	. . . . .
Salt, without cooperage . . . . . bbls.	2,172,000	35	760,200 00	5,538,855 17
Cooperage . . . . . bbls.	1,628,961	26	423,540 00	. . . . .
Clay products	. . . . .	. . . . .	415,730 00	2,236,664 00
Gypsum cement plaster . . . . . tons	61,103	4 30	262,743 00	2,086,016 00
Gypsum land plaster . . . . . tons	2,451	2 00	4,902 00	. . . . .
Stone, building (estimated) . . . . . cu. yds.	. . . . .	. . . . .	250,000 00	. . . . .
Stone, crushed, for railroad ballast	400,000	75	300,000 00	3,978,923 00
Natural gas	. . . . .	. . . . .	257,500 00	1,049,764 00
Oil, crude . . . . . bbls	69,556	75	52,167 00	410,671 53
Oil, refined, including gasoline and fuel oil	. . . . .	. . . . .	225,760 00	. . . . .
Hydraulic cement . . . . . bbls.	140,000	45	63,000 00	724,466 00
Lime (estimated)	. . . . .	. . . . .	65,000 00	1,380,000 00
Sand (estimated)	. . . . .	. . . . .	50,000 00	450,000 00
METALLIC PRODUCTS.				
Zinc ore, 63,369 tons, worth $2,313,831, yielding metallic zinc . . . . . tons	32,354.2	115 00	3,720,733 00	43,456,227 92
Lead ore, 6,733.39 tons, worth $354,311, yielding metallic lead . . . . . tons	4,992.6	90 00	449,344 00	
SMELTING PRODUCTS.				
Zinc smelting . . . . . tons	52,664	115 00	6,056,360 00	35,721,702 03
Lead smelting . . . . . tons	1,666.6	90 00	150,000 00	5,320,277 01
Argentine refinery	. . . . .	. . . . .	20,028,385 00	147,430,323 67
Totals	. . . . .	. . . . .	$38,889,612 00	$309,995,300 14

I.—GOLD AND SILVER.

Gold and Silver Ores.

WE have no mines in our state producing either gold or silver ores. In the Mineral Resources of Kansas for 1897, beginning on page 14, and again in the corresponding report for 1898, beginning on page 13, was given a tolerably full discussion of the different reported finds of gold ore and silver ore in different parts of the state, particularly in Trego and Ellis counties. Since the appearance of the report for 1898 no new discoveries have been reported from that part of the state. On the contrary the excitement has gradually decreased, until for the last few months nothing has been said by the public press upon the subject. It is presumed, therefore, that the investigations made by different parties yielded negative results. During the summer and early autumn of 1899 it was reported that a number of car-loads of the so-called auriferous shales were shipped to Colorado smelters for experimental purposes, and different reports were made public of the results obtained from assays of the shipment, but so far as this department has learned no reports have been made public of the results by actually smelting the ore. It is now generally admitted that the position taken in our former reports, namely, that the Cretaceous shales of Ellis and Trego counties carry no gold or silver, was substantially correct in every respect; and that there is no longer good ground for reasonable hope of gold being found in paying quantities in that part of the state.

Quite recently, during the first few months of 1900, reports were sent out from Galena to the effect that large quantities of a comparatively low-grade ore had been discovered in that vicinity. An effort was made at once to secure representative

samples of the reported ore for careful examination in the laboratories of the University. In all, fourteen different samples have been carefully assayed, either by Prof. H. P. Cady, of the assay department, or under his immediate direction. The methods employed were the most recent and reliable known to assayers. Not a single one of the fourteen samples yielded an appreciable quantity of either gold or silver. It is reported that different parties have sent samples of the same ore to different assayers in Colorado and other Western states, almost all of which showed the presence of a small amount of gold ore and traces of silver ore, the richest ore yielding a little over forty dollars in value to the ton. Why the careful analyses made by Professor Cady should fail to show even a trace of gold or silver, while other assayers were obtaining from two dollars to forty dollars per ton, is difficult to explain, for the assays made here certainly were made with the greatest of care, by an experienced assayer, who used chemically pure reagents and the best patterns of modern apparatus throughout.

The so-called gold ore comes from the bluffs along the south side of Shoal creek, to the southwest of Galena. The original so-called gold ore consists of the ordinary yellow residual clays and the flint rock so common to that part of the country, and probably some of the samples also contained some other material, although those sent to the University were the clays and flint rocks only. It is reported in the press that experienced gold miners from the West made the discovery, and that a strong company was organized, consisting partly of local men, but principally of gentlemen from Colorado, and that the company has obtained leases on a large tract of ground for the purpose of operating mines for the precious metals. At this writing, May 15, it is learned that four or five large shafts are being sunk on the leased lands for the purpose of future operations on a grand scale. The rumors of the discovery of gold have attracted considerable outside attention, and many newcomers are said to have reached Galena on that account.

It invariably renders unpopular one who makes use of a public position to discourage a belief in the existence of gold or

silver in any locality from which it is reported; nevertheless, the present Geological Survey of Kansas being supported by the state, and therefore by the taxpayers of the state, it is due the masses of the people that they should be given an unbiased report of the actual conditions obtaining in the locality wherein the precious metals are supposed to exist. It is also somewhat hazardous to make predictions for the future regarding the probable discovery of the precious metals in any locality which has not been thoroughly explored for them; yet there are certain fundamental principles of ore deposition which seem to be established, and predictions of future development well based upon such principles generally prove to be verified. There is perhaps no gold or silvermining locality in the world rich in other metalliferous ores without a considerable proportion of gold and silver being immediately associated with the other ores. One would suppose, therefore, that if the Galena district contains any considerable quantity of gold or silver the lead and zinc ores found so abundantly over so wide an area would contain at least considerable proportions of the precious metals; yet, it is a well-known fact that dozens and probably hundreds of assays and chemical analyses have been made from the various lead ores and zinc ores of southwestern Missouri and southeastern Kansas without a single discovery of any considerable amount of either gold or silver, and particularly without the discovery of gold. Some of the assays have shown the presence of small quantities of silver, but not a single one yet published has shown a sufficient amount of gold and silver combined to justify the separation of the precious metals from the lead or zinc. With this well-known fact before us, it is difficult to understand how it would be possible for practically the same locality to contain enough gold and silver to make mining for them a profitable industry.

During the past year perhaps not a single month passed without some one sending samples to the University to be assayed for gold or silver, such samples coming from many different localities in eastern Kansas. The feverish condition produced by the vigorous agitation of the gold-mining spirit in western Kan-

sas seems to have borne more fruit in the eastern part of the state than elsewhere. The area referred to in the 1898 report, page 16, situated around the northwest corner of Bourbon county, has produced nothing, and as far as can be learned the interest in that locality has entirely disappeared. The samples sent in from other parts of the state have been exceedingly varied, some of them being pieces of limestone, others ordinary shale, and a number of them from the northeastern part of the state were samples of decomposing granite and other crystalline rocks of the glacial drift, in some of which were developed little scales of a beautiful golden-yellow mica, which frequently deceives those not well versed in mineralogy.

Gold and Silver Smelting.

The only smelter and refinery for the precious metals located within the state is the one at Argentine. During the year 1899 the management of that establishment was changed by the refinery being purchased by the American Smelting and Refining Company, commonly spoken of as the "combine." The amount of business done at the refinery during the past year was much greater than that of any year in its history, aggregating more than $20,000,000, reckoning the silver refined at the commercial value, or more than $27,000,000 by reckoning the silver produced at its coinage value. The total amount of gold produced was 426,786 fine ounces, having a value of nearly $9,000,000. The amount of silver produced was 10,513,106 fine ounces, with a coinage value of $13,592,395, or a commercial value of $6,255,298. The copper obtained from the bullion refined was marketed in the form of blue vitriol, as has been done during the past three years. The total production of this material reached nearly 7,500 tons, with a commercial value of a little over $700,000.

In the refining process a considerable amount of zinc is used which may be recovered profitably. This was changed into the sulphate, or white vitriol, and marketed as such, the product being over 550 tons, with a value of a little more than $17,000. The lead produced by the refinery in 1899 was sold as lead,

aggregating a little more than 49,000 tons, with a value of $4,500,000. During the year 1897, the lead was principally changed to litharge or the red oxide of lead, and marketed in that form, but for the past two years it has been found more profitable to market the lead in the metallic state. The following Table II shows the output and value of the various products of the Argentine refinery for 1899 and the total production since the refinery was established.

TABLE II.

SHOWING OUTPUT OF THE ARGENTINE SMELTING AND REFINING COMPANY FOR 1899 AND FOR ENTIRE PERIOD OF OPERATION.

Gold and silver expressed in fine ounces, copper and litharge in pounds, and lead, white vitriol and blue vitriol in tons. Fractions omitted.

PRODUCT.	1899.			Total production during operation of plant.		
	Amount.	Coinage value.	Commercial value.	Amount.	Coinage value.	Commercial value.
Gold..............oz.	426,786.00	$8,821,676 00	$8,821,676 00	1,530,196.00	$31,631,284 35	$31,631,284 35
Silver.............oz.	10,513,106.00	13,592,395 00	6,255,298 00	138,256,621.00	178,751,985 29	76,622,956 63
Copper...........lbs.	....	....	....	a 9,000,000.00	....	990,000 00
Blue vitriol..... tons	7,467.00	....	709,365 00	b 27,947,833.00	....	1,067,314 14
White vitriol.....tons	553.00	....	17,296 00	c 1,397,011.00	....	23,116 22
Litharge..........lbs.	....	....	....	d 2,881,124.00	....	112,353 00
Lead............tons	49,125.00	....	4,224,750 00	495,903.93	....	37,197,552 25
Total values........	....	$22,414,071 00	$20,028,385 00	....	$210,383,269 64	$147,430,723 67

a Production of 1894, 1895, and 1896. *b* Production since July 1, 1897.
c Production of 1898 and 1899. *d* 1897 only.

II.—LEAD AND ZINC.*

THE year 1899 was the most prosperous year in connection with the various phases of lead and zinc mining and smelting ever known to our state, surpassing even that of 1898. This is particularly true of the zinc-smelting industry, which far surpassed in tonnage and value of product the output of 1898, or any other previous year.

LEAD-ORE AND ZINC-ORE MINING.

Galena District.

During the past year the territory covered by active mining operations in the Galena district was practically the same as that occupied during the previous years. There was a slight expansion in almost every direction, due to the unprecedented activity in mining and mill building. But the greater part of this activity was manifested in the erection of mills in old territory previously worked without them, so that in geographic area but little expansion was witnessed. During the first half of the year, particularly, and throughout the remaining part to a lesser extent, the activity in mill building was most remarkable.

In August, 1898, an accurate enumeration of the mills engaged in ore dressing in Kansas territory was made, the number aggregating 53; likewise, again, during the latter part of August, 1899, a new census of the mills was taken, at which time it was found that the number had increased to 97. These mills were principally erected by outside capital, and, to a certain extent, reduced the output of the district for a short time.

*As our final report on lead and zinc will be completed during the next fiscal year, the discussion of this subject is made much briefer than it otherwise would be.

In almost every instance where a mill was building a large or small mining property was purchased, and was practically shut down during the time of the erection of the mill. As building material was scarce, and contractors were from one month to three months behind with their contracts, it was necessary to shut down many mines during a period of from two to six months — mines which previously had been worked and the ore sold in the rough or dressed by hand.

The rapid decline in the price of zinc ore during the latter part of the year again caused different mines to close temporarily, and the two shut-downs ordered by the Zinc Producers' Association, one for two weeks and the other for nearly a month, were so generally observed that they also assisted in reducing the total output. The tonnage production for the year is therefore considerably below that of 1898, as will be seen by a comparative study of the production tables following. Thus, the total tonnage of zinc ore in 1898 was 74,166.65, while in 1899 it dropped down to 64,708.48 tons of marketable ore.

The production of lead ore in 1898 was 7,599 tons plus, while in 1899 it was only 6,733 tons plus. But the extraordinarily high price of zinc ore during 1899 was sufficient to make the total value of production greater than for 1898, or for any year previous. The average price per ton of zinc ore for 1898 was estimated at $27.63, and for 1899 the average was $38.54. The average price of lead ore per thousand pounds during 1898 was estimated at $22.18, while for 1899 it was $26.31.

The total value of the production of our lead and zinc mines on Kansas territory in 1898 was given at $2,347,028 by one estimate and $2,236,364 by another, while for 1899 the figures reached the princely sum of $2,668,142.

The high price of ore during the year, one might think, rendered mining unusually profitable. A more detailed examination of the conditions prevailing, however, reveals the fact that other commodities, both material and labor, advanced at about the same ratio, and that therefore the net profits were little, if any, greater to the mine operator than during previous years. Mining material of all kinds advanced in price rapidly, in ac-

cordance with the advance of similar materials elsewhere. This affected every article used in mining operations, whether metallic or wooden. The price of iron and steel was practically doubled, that of lumber increased fifty per cent. or more, and powder for blasting increased in a similar manner.

It is sometimes argued that labor is the least responsive of any commodity the manufacturer employs. But in the mining district labor advanced almost as rapidly as did the price of ore. The workmen who three years before were generally receiving $1.50 per day each now, in most cases, were paid $2.25 per day; while ground foremen, who had worked at $2 per day, were now paid from $2.50 to $3 per day.

There is a custom in the lead and zinc mines as old as the mines themselves for nine hours to constitute a day's work for all laborers, excepting those immediately connected with the operation of the ore-dressing mills, where ten hours constitute a day's labor. With wages ranging from two to three dollars per day for labor and nine hours being counted for a day, and with all materials used in connection with the mine operations being at the exceptionally high prices witnessed during 1899, a mine had to be comparatively rich and the output comparatively large if the pay-roll and merchant's bills for the week did not exceed the amount received from the ore marketed.

The mining methods employed in the Galena district are in most respects similar to those employed earlier, with the exception that everything is done on a larger scale. Thus, in blasting ten years ago the ordinary shot in breaking ground rarely exceeded two sticks of giant powder, and the hole drilled to receive the powder rarely exceeded two or three feet. Now it is not uncommon for the holes to be drilled from four to six feet in depth while stoping, and from twenty to thirty sticks of powder to be exploded at one time. The mode of underground haulage is correspondingly improved. In early days the tubs were pulled to the hoisting shaft from the end of the tunnel by hand, sliding them on a board or slab rendered partially frictionless by a liberal application of "tallow clay." Now in all cases tramways are built by the use of iron rails, and the tubs

are placed on trucks which ply back and forth on the tramway, carrying the tubs to and from the hoisting shaft.

Now the hoisting is always done by steam power, excepting in a few small mines and outlying prospecting shafts; while formerly the steam hoister could scarcely be found, but the hand windlass and horse power were considered all that was necessary.

Likewise the surface haulage has been greatly improved. Elevated tramways now are generally employed, on which iron rails are placed to carry the tubs from the shaft to the mill. In many cases these tramways are elevated on high trestles to altitudes of 20 or 30 feet and shafts from 100 to 300 or 400 feet distant from the mills are connected so that the tubs used in hoisting may be quickly pushed from the top of the shaft to the crusher. There is also a general tendency to increase the size of the tubs used. Three years ago it was difficult to find one with a capacity greater than 500 pounds of ore, while at present, and particularly at the mills built during the present year, tubs with a capacity two and three times as great are being introduced.

Lead and Zinc Ores in Other Parts of the State.

No mining for lead and zinc ores has been conducted successfully outside the Galena district anywhere within the state during 1899. The mines at Pleasanton, mentioned on page 23 of the 1898 report, have produced nothing in marketable quantities. The shale beds at this locality seem to contain a surprisingly large amount of lead ore and small quantities of zinc ore, but have not yet produced them in marketable quantities. A considerable amount of money has been spent in prospecting, without satisfactory results.

Nothing has been heard from the Xenia area, mentioned on page 22 of the 1898 report, nor has any ore been sent to the market from the Ellis-Trego county district during the year.

The surprising feature of eastern Kansas, however, is that zinc blende is found over so wide an area. Almost every county in the eastern fourth of the state has produced small quantities

of this ore. Samples have been sent to the University for examination almost by the hundred. The ore generally occurs in fissures and fracture openings of limestone or concretionary calcareous nodules imbedded in the shale. The latter form occurs particularly in Osage, Douglas and Jefferson counties. Many samples have been sent in consisting of rounded concretionary masses from three inches to fifteen and eighteen inches in greatest diameter, the fissures in which are principally filled with zinc blende more or less associated with calcite. It would seem that in these counties the ore is more frequently found in the fissures of the concretionary masses than in the true limestone itself.

Many citizens of the state have become unduly enthusiastic over the discovery of such small amounts of zinc blende. The popular, and yet somewhat fallacious, idea is wide-spread that if a little ore is found near the surface large quantities will be found by going deeper. In fact, some objections have been made to the discouraging advice sent out from the University to parties who have made discoveries of zinc blende, as above stated, and have had great faith that profitable zinc-ore mines could be found by extended prospecting. I cannot do better than to quote a few paragraphs from my 1898 report regarding the probabilities of valuable discoveries of ore being found in eastern Kansas outside the Galena district:

No encouragement can be given, however, for the belief in the existence of either zinc ore or lead ore throughout this region in sufficiently large quantities to make mining operations profitable. The general geological conditions in the Coal Measure areas of the state are such that it is exceedingly doubtful if large deposits of any kind of mineral products could have been formed. There is no mining region in the world where metalliferous ores have been segregated to any great extent that is not also one of great thickness of hard, firm rock. Ore deposits must be found in places where fractures and openings exist in the rock mass. If earthquakes and other earth movements have been sufficiently vigorous to break and fracture the rocks in a given area, one step has been taken in producing the essential conditions for ore deposition. If these rocks are hard and firm, so that the openings will remain open, allowing the free passage of water, ore deposition may occur. If, on the other hand, the rock mass is soft and yielding, such as the Coal Measure shales, the openings will not have been produced in them to so great an extent, and where produced soon become filled by the falling in of material from the sides, so that the free and abundant passage

of water is prevented. This is well illustrated by the universal fact that heavy shale beds carry little water.

An examination of the general geologic conditions of the Coal Measure shales of Kansas reveals the fact that upon an average we have four feet of shale to one foot of limestone. This has been illustrated and emphasized in Volume III of our University Geological Survey reports. . . .

The different shale beds in the Coal Measure area vary greatly in thickness, with a maximum of about 500 feet. If the earthquake movements which so effectively fractured the flint rocks in the Galena-Joplin area were as severe farther west these heavy shale beds would scarcely show the effects of such earth tremors, and were they sufficiently strong the actual fractures in the shale beds would remain open but a short time before they would be filled up. Therefore the openings produced in the limestones, which probably would be retained, would avail but little on account of the heavy shale beds above and below acting as barriers and rendering the free circulation of water impossible.

This department is now in possession of a few facts which have direct bearing on this question that may be mentioned in this connection, although no detailed publication has yet been made. In our study of the coal-fields it was found that the "horsebacks" are far more abundant in Cherokee and Crawford counties than in the coal-beds in other parts of the state. These "horsebacks" are simply the results of fractures in the coal, which fractures have been filled, principally from below, by fire-clay and other clay products being squeezed into the openings, as is fully explained in Volume III. The existence of fractures in such superior numbers in Cherokee and Crawford counties, in connection with the fact that they almost universally trend northeast or southwest, is most readily explained by associating their origin with the general earth movements which produced the Ozark uplift to the southeast.

It seems when this area was elevated earthquakes or similar movements fractured the rocks to a great extent, producing a peculiar and unusual set of openings throughout the whole Galena-Joplin mining district. In this district, however, the rocks are hard and firm to as great a depth as deep borings have been carried; that is, at least to 1000 feet. The openings, therefore, retained their form and made the circulation of water most easily accomplished. But passing westward into the Coal Measures the area is farther removed from the source of the fractures, and in addition it contains the heavy beds of shale, which of themselves probably would have prevented extensive ore depositions.

There are therefore two reasons for having greater faith in extensive ore deposition in areas now occupied by lead- and zinc-mining operations than in any other parts of eastern Kansas. Discoveries of ore probably will be made here and there in many new localities, and occasionally considerable amounts may be found in the most favorable positions. But it is the opinion of this department, based upon a tolerably detailed knowledge of the geological conditions of the whole eastern part of the state, that there will never be developed extensive metalliferous deposits in any of the rock formations variously associated with the Coal Measure shales.

Prices of Lead and Zinc Ores.

During the year 1899 the prices for zinc and lead ores were the highest known for years, and the highest ever known for zinc ores. The following Table III is self-explanatory. It should be stated that while slight errors are known in the table, no way of correcting them is available. The state line separating Kansas from Missouri is so close to Galena that small quantities of ore from Missouri are occasionally sent to the mills in Kansas for dressing, and hence become included in the statistics for Kansas. Other slight errors of a similar nature are known, but data for their correction cannot be gathered.

It also will be noted that the totals in tonnage multiplied by the average prices aggregate a little more than the total value of the two products. This results from the average monthly values being a little too high. The price for zinc ore varies so with the quality that every individual purchase should be reckoned separately to obtain exact results, a task well-nigh impossible. The monthly prices represent about the average for sixty per cent. ore, while the total values represent the total cash payments for each month.

Zinc Smelting.

During the year 1899 the zinc smelters of Kansas produced by far the largest amount of metallic zinc ever produced in a single year, aggregating 52,664 tons, which, at a value of $115 per ton in New York, reaches the surprising amount of over $6,000,000, nearly double in value the output in any previous year. These large figures are due to two considerations: First, to the unprecedentedly high price of spelter, the average of $115 per ton being the highest for any recent year; and, second, to the great demand the market sustained for metallic zinc. The tonnage product for the state is nearly 150 per cent. that of 1898, which, at its time, was the largest ever known.

The establishment of zinc smelters in the natural gas fields of Kansas has had a strong tendency to increase the amount of zinc ore smelted and relatively decrease the output of the Illinois and Missouri smelters, so that a much larger proportion of

TABLE III.

SHOWING AMOUNT AND VALUE OF ZINC ORE AND LEAD ORE IN THE GALENA AREA compared with amount and value of same ores for the whole Galena-Joplin area, 1899.

(Data gathered from reports of Joplin correspondent in *Engineering and Mining Journal.*)

Month.	Product and value of Kansas area in 1899.					Product and value of Kansas and Missouri area in 1899.					Per cent. Kansas production is of whole area, 1899.	
	Zinc ore. In tons (2,000 lbs.) and dollars.		Lead ore. In 1,000 lbs. and dollars.		Total value.	Zinc ore. In tons (2,000 lbs.) and dollars.		Lead ore. In 1,000 lbs. and dollars.		Total value.	Zinc ore.	Lead ore.
	Product.	Price.	Product.	Price.		Product.	Price.	Product.	Price.			
January	5,636.47	$40 25	1,021.10	$23 94	$192,368	29,602.25	$32 25	4,260.57	$23 94	$820,068	19.04	24.03
February	2,980.77	43 37	783.50	26 50	139,490	12,721.41	43 37	2,615.13	26 50	579,411	23.58	26.13
March	6,797.23	43 40	1,263.15	25 80	295,231	20,905.22	43 40	4,510.28	25 80	1,116,407	32.51	28.00
April	5,900.00	51 50	1,006.51	22 25	281,823	25,571.79	51 50	4,560.82	25 25	1,234,674	22.99	24.26
May	5,895.76	50 50	1,276.34	26 00	281,226	23,972.38	50 50	4,220.12	26 00	1,132,247	24.59	30.24
June	6,817.13	45 50	1,211.72	26 00	288,284	23,883.89	45 50	4,517.62	26 00	1,278,069	28.54	26.81
July	5,111.05	44 20	1,124.45	26 90	218,592	20,522.34	44 22	3,376.42	26 90	855,910	24.81	33.33
August	5,909.18	45 00	1,078.27	27 25	228,604	26,112.90	45 00	4,459.87	27 25	1,133,894	22.66	24.17
September	4,025.85	43 75	1,164.06	27 00	192,283	18,777.07	43 75	4,921.76	27 00	846,040	21.39	25.63
October	4,331.98	43 50	913.70	26 90	183,308	17,661.66	43 50	3,263.39	26 90	723,287	24.55	28.91
November	5,498.11	35 00	1,410.97	27 20	166,595	20,549.50	35 00	4,548.75	27 20	724,718	26.75	31.23
December	5,804.95	36 00	1,180.02	27 00	200,338	24,743.54	36 00	4,735.17	27 00	900,834	23.45	24.92
Totals and averages,	64,708.48	$38 54	13,446.79	$26 31	$2,668,142	265,025.95	$38 54	48,989.83	$26 31	$11,350,589	24.24	27.48

the zinc ore from the Joplin-Galena district is smelted on Kansas soil.

The total amount of spelter produced in America for 1899, according to statistics kindly furnished by the *Engineering and Mining Journal*, is 123,194 tons. The production of our Kansas spelter, 52,664 tons, is therefore 42.74 per cent. of the total spelter production in America.

During the year a number of large zinc smelters were established. The Lanyon Zinc Company, of Iola and Pittsburg, was organized by the consolidation of the Robert Lanyon's Sons Company, the W. & J. Lanyon Company, and the Palmer Oil and Gas Company. By this combination the two largest companies operating gas smelting furnaces were combined with the company owning the largest number of gas wells in the state. They enlarged their plant, both at Iola and La Harpe, so that they now are by far the largest zinc smelting company in the state. At Gas City, the company started its furnaces during the year. The Geo. E. Nicholson Zinc Company, at Iola, started its plant early in 1899, and the Edgar Zinc Company, at Cherryvale, began the production of spelter in June, 1899. The plant of the latter company, in some respects, is quite different from the other smelting plants. They use the Brown patent calcining or roasting furnace for desulphurizing the ore.

The furnaces using coal for fuel were not increased in number during the year to any considerable extent. The Bruce Mining and Smelting Company, at Bruce, Crawford county, Kansas, completed their plant of four blocks of coal furnaces.

The total smelting capacity of the Kansas furnaces at present is about as follows: Furnaces using gas for fuel, 15,220 retorts; furnaces using coal for fuel, 8816 retorts. Were all of these furnaces kept in blast the entire year they would produce more than 100,000 tons of spelter. During 1899, although the price of spelter rose so high and the market demands were so great, many of the furnaces were closed during a large part of the year. A part of the Lanyon furnaces at Iola were destroyed by fire, so that a great delay was necessitated during the time of rebuilding. There was scarcely a coal smelting furnace in

the state which ran more than three-fourths of the time. The shut-down was in some instances for repairs, while in other cases the conditions of the ore and spelter market were such, it was claimed, that it was more profitable to allow the furnaces to lie idle than to operate them. What will be done in the future, with the smelting capacity more than doubled during the last two years, is a question the answer to which will be watched with interest.

Table IV shows the amount and value of the total spelter production for Kansas for 1899, and for the seventeen years preceding.

TABLE IV.

SHOWING AMOUNT AND VALUE OF METALLIC ZINC PRODUCED AT KANSAS SMELTERS, 1882 TO 1899, INCLUSIVE.

Price per ton in New York.
(Data 1882 to 1896 from United States Geological Survey statistics.)

YEAR.	Amount in short tons. (2000 pounds.)	Price per ton in New York.	Total value.
1882..........	7,366	$110 60	$814,679 60
1883..........	9,010	90 60	816,306 00
1884..........	7,859	89 60	704,466 40
1885..........	8,502	86 80	737,973 60
1886..........	8,932	87 90	785,122 80
1887..........	11,955	92 80	1,109,424 00
1888..........	10,432	98 34	1,025,902 88
1889..........	13,658	100 20	1,368,531 60
1890..........	15,199	108 75	1,652,891 25
1891..........	22,747	108 82	2,475,336 96
1892..........	24,715	89 78	2,218,912 70
1893..........	22,815	80 37½	1,733,755 63
1894..........	25,588	70 43	1,902,162 84
1895..........	25,775	71 04	1,831,056 00
1896..........	20,759	79 70	1,653,592 30
1897..........	33,443	82 40	2,755,703 20
1898..........	38,543	91 40	3,508,524 27
1899..........	52,664	115 00	6,056,360 00
Total for 18 years..	....	....	$33,149,702 03
Estimation of zinc smelted previous to 1882..................................			2,575,000 00
Grand total..........................			$35,724,702 03

The World's Production of Metallic Zinc.

The great moneyed interest Kansas has in the production of lead and zinc ores, and her large interests in zinc smelting, render any information on the world's production of these commodities desirable at all times. There is a wide-spread idea in the zinc ore mining districts that the American production is sufficiently large to warrant the American producers in attempting to control, as far as possible, the markets of the world. Many false stories have been circulated throughout the Galena-Joplin district during the last eighteen months to the effect that the foreign mines and smelters were constantly decreasing their output, and that therefore the price of spelter must necessarily advance rapidly, on account of the decrease of the foreign production and the increase of normal consumption. These stories are frequently coupled with greatly exaggerated statements regarding the new uses for metallic zinc, and the probable conditions which will have an enhancing or depreciating influence on the markets of the world. It is, therefore, interesting to note the exact conditions as shown by reliable statistics. Table V gives the world's production of metallic zinc for 1884 to 1899, inclusive, a period of sixteen years.

It will be seen that, without a single exception, after 1886 the total foreign production increased steadily, yet rapidly, reaching the magnificent sum of 372,496 tons of metallic zinc produced in 1899. The same table shows the American production for a like period of years. These figures are not so regular as those for foreign countries, there being two reversals in output, the first in 1893 and 1894, the second in 1896. The increase in production for 1899, however, is quite marked, and corresponds very closely with the increase in the total zinc ore production in the Galena-Joplin district. In 1898 the total production for the Joplin district was 224,689 tons of ore, while for 1899 it was 265,025 tons. The total amount of American spelter production for 1898 was 103,515 tons, while for 1899 it was 123,194 tons. It must be confessed, however, that it is probable the figures giving the total tonnage of ore are somewhat

TABLE V.

SHOWING WORLD'S PRODUCTION OF METALLIC ZINC FROM 1884 TO 1899, INCLUSIVE.

(From Nineteenth Annual Report Director United States Geological Survey, part VI, pp. 223 and 224; foreign figures reported by Henry M. Merton & Co., London, England. Figures for 1898 and 1899 from *Engineering and Mining Journal.*

YEAR.	Rhine district and Belgium.	Silesia.	Great Britain.	France and Spain.	Austria.	Poland.	Total foreign.	America.	Grand total.	Per cent. American.
1884	127,240	76,116	29,259	15,341	6,170	4,164	260,290	34,414	294,704	8.56
1885	129,754	79,623	24,299	14,847	5,610	5,019	259,152	36,329	292,659	8.05
1886	129,020	81,630	21,230	15,305	5,000	4,145	256,330	38,072	294,402	12.93
1887	130,995	81,375	19,839	16,028	5,388	3,580	257,155	44,946	302,101	14.87
1888	133,245	83,375	26,783	16,140	4,977	3,785	268,305	49,913	318,218	15.68
1889	134,648	85,665	30,806	16,785	6,330	3,026	277,248	52,553	329,801	16.23
1890	137,630	87,475	29,145	18,240	7,135	3,620	283,245	57,860	341,105	16.96
1891	139,695	87,080	29,410	18,360	6,440	3,760	284,745	72,208	356,953	20.22
1892	143,305	87,760	30,310	18,662	5,020	4,270	289,327	77,910	367,237	21.21
1893	149,750	90,310	28,375	20,585	7,560	4,530	301,110	70,385	371,495	18.93
1894	152,420	91,145	32,065	21,245	8,580	5,015	310,470	67,257	377,727	17.80
1895	172,135	93,620	29,495	22,895	8,355	4,960	331,460	80,077	411,537	19.45
1896	179,730	95,875	25,880	28,450	9,255	6,165	345,355	72,767	418,122	17.43
1897	184,455	94,045	23,430	32,120	8,185	5,760	347,995	89,268	437,263	20.41
1898	191,836	99,233	27,635	32,649	7,229	5,664	364,246	103,515	467,761	22.10
1899	192,994	100,160	32,223	33,482	7,305	6,325	372,496	123,194	495,690	26.87

TABLE VI.

SHOWING AVERAGE MONTHLY AND YEARLY PRICE OF METALLIC ZINC—"SPELTER"—IN NEW YORK FROM 1893 TO 1899, INCLUSIVE.

(Partly from *Engineering and Mining Journal*, January 7, 1899, page 21, and January 6, 1900, page 19.)

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	cts.	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*
1893	4.39	4.39	4.28	4.38	4.41	4.27	4.13	3.89	3.69	3.68	3.65	3.80	**4.08**
1894	3.56	3.85	3.89	3.62	3.37	3.40	3.43	3.38	3.44	3.45	3.36	3.43	**3.52**
1895	3.28	3.20	3.23	3.30	3.50	3.65	3.75	4.15	4.30	4.10	3.55	3.49	**3.63**
1896	3.75	4.03	4.20	4.09	3.98	4.10	3.97	3.76	3.60	3.72	3.99	4.14	**3.94**
1897	3.91	4.02	4.12	4.13	4.21	4.21	4.32	4.26	4.18	4.17	4.03	3.89	**4.12**
1898	3.96	4.04	4.25	4.26	4.27	4.77	4.66	4.58	4.67	4.98	5.29	5.10	**4.57**
1899	5.34	6.28	6.31	6.67	6.88	5.98	5.82	5.65	5.50	5.32	4.64	4.66	**5.75**
Av. for 7 years,	**4.03**	**4.23**	**4.18**	**4.35**	**4.40**	**4.34**	**4.28**	**4.24**	**4.20**	**4.21**	**4.07**	**4.08**	**4.23**

above the actual production, as that quantity of zinc ore should have yielded more metallic zinc than the total production for America, as shown in table V. The statistics show, however, that relatively America produced a small proportion of the total world's production, and therefore the apparent futility of attempting to affect permanently the markets of the world by temporary shut-downs of the mines and mills in the Galena-Joplin district.

The Spelter Market.

The spelter market for the year 1899 was unusually high, the average New York price for the year being $5.75 per 100 pounds. Table VI gives a summary of the monthly and yearly averages for the past seven years. According to this table the lowest average was for 1895, which was equal to $3.63, and the highest was for 1899, as above given. The average for the seven years from 1893 to 1899, inclusive, is $4.23. The highest monthly average during the past year was in May, when the price reached $6.88. From this time it gradually decreased to December, when the price was $4.66.

It is interesting to note in this connection the monthly price of zinc ore as shown in table III. It will be seen that there is a close correspondence between the price of ore and the price of spelter, as the price of ore gradually increased from January to April, and decreased again with but little interruption to the end of the year.

The question of a fair margin between the price of ore and the price of spelter is one of great interest, particularly to the ore producers. Table VII gives a statement of the ratio between these two values for the years 1886 to 1899, inclusive, from which may be learned something of the profits made by the zinc smelters. It will be seen that for the year 1886 one ton of spelter in New York would purchase 4.69 tons of ore in the Galena-Joplin district. This ratio between the value of a ton of spelter at New York and a ton of ore at the mines is variable, reaching the highest point in 1891, when one ton of spelter in New York would purchase 5.05 tons of ore at the

mines. Following down the column it will be seen that this ratio gradually decreases until, in 1899, one ton of spelter would buy only 2.98 tons of ore.

TABLE VII.

SHOWING PRICE PER TON OF ZINC BLENDE AT GALENA-JOPLIN,

From 1886 to 1899, inclusive, and price per ton of metallic zinc in New York, with ratio between the two; also, price per ton of metallic zinc in sixty per cent. zinc ore and difference between this and New York price.

YEAR.	Price per ton of zinc blende in Galena-Joplin. (2000 lbs.)	Price per ton of metallic zinc in New York. (2000 lbs.)	Ratio between price of zinc blende and metallic zinc.	Price per ton of metallic zinc in 60-per-cent. ore. (2000 lbs.)	Difference between price per ton of zinc in 60-per-cent. ore and New York price.
1886	$18 50	$87 90	1:4.69	$30 83	$57 07
1887	19 00	92 80	1:4.88	31 67	61 13
1888	21 00	98 34	1:4.68	35 00	63 34
1889	24 00	100 20	1:4.17	40 00	60 20
1890	23 00	108 75	1:4.72	38 33	70 42
1891	21 51	108 82	1:5.05	35 85	72 97
1892	20 00	89 78	1:4.48	33 33	56 45
1893	18 85	80 37½	1:4.28	31 42	48 95
1894	17 10	70 43	1:4.09	28 17	41 26
1895	19 68	71 04	1:3.60	32 80	38 24
1896	22 51	79 70	1:3.54	37 45	42 25
1897	25 17	82 40	1:3.27	41 82	40 58
1898	27 63	91 40	1:3.30	46 05	45 35
1899	38 54	115 00	1:2.98	64 23	50 77
Averages..	$25 32	$98 35	1:4.12	$37 64	$53 49

The relative value of zinc in the ore and zinc after smelting, as shown in the two right-hand columns, is also an interesting item. In 1886 the value of a ton of zinc in sixty per cent. ore was only $30.83, while the same ton of zinc after smelting had a value in New York of $87.90, leaving a margin of $57.07. To state this another way, of the $87.90 obtained for a ton of spelter $30.80 had to be paid for ore, leaving $57.07 for the cost of transportation, loss in smelting, expense of smelting, and profit. The loss in smelting is so great that sixty per cent. ore yields upon an average but little more than fifty per cent. of metallic zinc, or two tons of sixty per cent. ore yield but little more than one ton of spelter, instead of one and one-fifth tons, as it would could the smelting operations be conducted without any loss.

The Uses of Spelter.

Great interest is manifested in the zinc mining districts regarding the uses to which spelter is applied. During the summer of 1899 many discussions were held regarding the causes for the fluctuation in the price of spelter. It was generally conceded that any cause which decreased the consumption would likewise decrease the price.

During the middle of the year, while irón was so high, a decline in the price of spelter was explained by some on the ground that iron was so high that the manufacture of galvanized ware was practically abandoned; hence the demand for spelter greatly reduced. Later, when the South African war began, and the Rand gold fields were closed, it was freely stated that the great decrease in the use of spelter in the cyaniding process for reducing gold ores was a great factor in the reduction of the price of spelter. Still another reason assigned for the decrease of spelter was that the combination of gold and silver refineries, which occurred early in the summer, resulted in the shutting down of some of the refineries, and, therefore, a decrease in the demand for spelter in the gold and silver refining processes necessarily decreased the price of the metal.

There may be some truth in all of these statements, yet it is probable the markets were but slightly affected by any of them, as the amount of decrease in the demand for spelter by any one of the causes assigned was almost unrecognizable. The amount used in the gold and silver refineries is so exceedingly small it could hardly influence the market. For example, at Argentine, in the refining of an amount of gold and silver equaling in coinage value more than $22,000,000, the zinc recovered was sufficient to produce only 553 tons of white vitriol, or zinc sulphate, an equivalent of less than fifty tons of metallic zinc. It is not known what fractional part of the spelter used was recovered, but in general it may be said that it was nearly all regained. In the cyaniding process for extracting gold and silver from their ores only a comparatively small amount of zinc is used. Theoretically a pound of metallic zinc should

regain two pounds of gold or four of silver. In practice there is a great loss of zinc, resulting in a much greater amount of it being used. But should the above figures be multiplied by ten or twenty it would still give a surprisingly small amount of zinc used in the cyaniding processes of the world, an amount so small that it could hardly be claimed to materially affect the spelter market of the world.

Recently a letter was written to the *Engineering and Mining Journal*, of New York, making an inquiry as to the disposition of the spelter which goes into the market. Mr. R. P. Rothwell, the editor, replied as follows: "I am informed that it is principally used in galvanizing, for brass and yellow metals, for electrical purposes, sheet metal, and in the cyanide processes. The consumption is about as follows: Twenty per cent. sheet, fifteen per cent. brass and yellow, fifty per cent. galvanized, and fifteen per cent. sundries. Of course these figures vary according to the conditions of the trade." It will be seen that for the whole of the zinc used for electrical purposes, for cyaniding purposes, and for gold and silver refining purposes, as well as for many other lesser uses, only fifteen per cent. is allowed, while for the manufacture of sheet zinc and for galvanized-iron ware a total of seventy per cent. is consumed. Therefore the great expanse of the market demand for spelter during recent years is due principally to an increased demand for sheet zinc and galvanized iron ware.

III.—COAL.

Coal Production.

THE total output of Kansas coal mines for the year 1899 was greater, both in tonnage and value, than ever before known in the state. According to figures kindly furnished by the Hon. Edward Keegan, State Secretary of Mining Industries, the total tonnage was 4,006,895 short tons of 2000 pounds each, with a value of $5,124,248.01, which is more than a quarter of a million tons in excess of the tonnage of 1898, the largest previous known, and a value of $931,089 greater than that of 1898, or $224,474 greater than that of 1894, the highest value previously known.

The increase in the output of the mines is pretty well scattered over the state, almost all the localities showing a slight gain on last year's production. The most remarkable gain is in Crawford county, an increase of 98,588 tons, followed by an increase of 81,733 tons in Osage county. Cherokee county dropped behind a little over 3000 tons, Leavenworth gained about the same amount, while Coffey county produced nearly 40,000 tons, much more than double the production for 1898. Cloud county, in the far west, reported but 400 tons in 1898, while for 1899 the report is 6,146 tons.

From the standpoint of geological structure the percentages vary slightly from those of last year. The Cherokee shales, which produce the coal for Cherokee, Crawford, Leavenworth, Bourbon and Labette counties, dropped from 94.14 per cent. production in 1898 to 91.54 per cent. production in 1899, while the other geologic horizons have correspondingly increased, particularly the Osage shales, which have increased from 4.67 per cent. to 7.37 per cent. The Cretaceous shales of the west

likewise have had a very considerable increase, but the increase in per cent. of the total state production is so small that it can hardly be noticed.

It is interesting to note that the Cherokee shales, lying at the base of the Lower Coal Measures, produce more than 90 per cent. of the coal mined in the state, and it is still more remarkable that the next greatest producer is the Osage shales, more than 2000 feet above the Cherokee shales. This is particularly so when it is recalled that the intervening shale beds, constituting so large a proportion of the 2000 feet, are almost all producers of coal, demonstrating that during their formation conditions obtained to some degree favorable for the accumulation of coal. If we were to consider the market value of the coals produced, that from the Osage shales would represent a greater per cent., as the selling price of coal mined in the vicinity of Osage City averaged nearly $2 per ton, while the selling price in Cherokee and Crawford counties was about $1.25 per ton.

The Coal Markets.

The coal market in Kansas during 1899 was unusually strong, the demand for coal being almost unlimited. One of the peculiar features of the market which is difficult to understand is the indisputable fact that the advance in the selling price at the mines was not nearly so great proportionately as the advance in the retail markets throughout the state. Thus, the average price per ton at the mine for 1898 was estimated to be $1.08½, while for 1899 it was but $1.25, an increase of 15.2 per cent. The general advance in the retail price in most places was from twenty-five per cent. to forty-five per cent. For example, in Lawrence, Leavenworth coal had retailed at $2.75 per ton for more than five years; during the winter of 1899–1900 the same coal retailed at $4 per ton, an increase of 45.45 per cent. Cherokee and Crawford county coal had retailed for five or more years at $3.50 per ton, while during the past year it reached $4.50 per ton, an increase of more than twenty-eight per cent. This advance in price began before the close of 1898, and reached

RI TO GEOLOGIC FORMATIONS;

8(	1894.	1895.	1896.*a*	1894.	1895.	1896.	1897.	1898.	1899.
	Estimated Value.			)utput by Geologic Formations.					
30	$33,600	$75,000	....						
04	1,295,768	1,013,612	$1,206,022						
21	2,262,295	1,517,936	1,229,691	8.796	85.99	74.94	93.32	94.14	94.72
90	7,650	5,000	1,200						
215	548,672	364,900	368,825						
306	73,095	40,750	14,176	1.619	1.02	.45	.82	.53	.62
....	....	....	....						
....	....	....	....	....	....	....	....	....	....
....	....	....	....						
,103	32,042	34,200	23,506						
....	....	....	....	.512	.77	.54	.26	.31	.26
214	5,625	10,050	9,184						
....	4,500	5,850	....						
,400	3,800	6,000	....						
,813	7,875	8,100	....						
....	2,000	3,900	....	8.587	8.70	5.97	5.96	4.67	7.36
....	900	1,850	....						
,900	555,021	462,313	324,250						
,900	17,500	11,250	....						
,866	9,250	11,250	....						
,800	6,533	6,000	....						
,800	8,060	6,500	....	.487	.34	....	.18	.01	.21
....	....	....	....						
,414	22,666	3,880	....						
,825	2,925	1,800	....						
,331	$4,899,774	$3,590,141	$3,227,357	....	....	....	....	....	....

are more nearly correct than those gath.

the highest point in January and February of 1900. The various mining companies in Cherokee and Crawford counties, which sold such large quantities of coal to the lead and zinc mining companies in the zinc mining district, kept a comparatively low price during the greater part of the year.

TABLE VIII.

SHOWING COAL PRODUCTION IN SHORT TONS (2,000 LBS.), 1880 TO 1889, INCLUSIVE.

With price per ton and value of yearly product.

YEAR.	Production in short tons (2,000 pounds).	Price per ton.	Value of yearly product.
1880*	550,000	$1 30	$715,000
1881*	750,000	1 35	1,012,300
1882*	750,000	1 30	975,000
1883*	900,000	1 28	1,152,000
1884*	1,100,000	1 25	1,375,000
1885	1,440,057	1 23	1,770,270
1886	1,350,000	1 20	1,620,000
1887	1,570,079	1 40	2,198,110
1888	1,700,000	1 50	2,550,000
1889	2,112,166	1 48	3,126,005
1890	2,516,054	1 30	3,170,870
1891	2,753,722	1 31	3,607,375
1892*	3,007,276	1 31½	3,954,568
1893	2,881,931	1 37½	3,960,331
1894	3,611,214	1 35⅝	4,899,774
1895	3,190,843	1 12½	3,590,141
1896	3,191,748	1 01⅛	3,227,357
1897	3,291,806	1 07	3,488,380
1898	3,860,405	1 08½	4,193,159
1899	4,096,895	1 25	5,124,248
Totals	44,624,201	....	$57,709,888
Output previous to 1880	3,000,000	$1 50	4,500,000
Grand totals	47,624,201	....	$60,209,888

*Figures for 1880 to 1884, inclusive, and 1892 taken from United States Geological Survey reports. All others taken from reports of State Inspector of Coal Mines.

IV.—OIL AND GAS.

DEVELOPMENTS in the oil and gas fields during 1899 were not particularly striking, and yet were of sufficient extent to add materially to the faith one may have in the comparative permanence of the fields.

OIL.

The greater part of the oil produced was that from the wells of the Forest Oil Company, which amounted to 69,556 barrels, 42 gallons each, with an estimated value at the well of seventy-five cents per barrel. The most productive wells are in the vicinity of Neodesha and Thayer. The wells around Peru, however, have produced some oil, and seem to be able to supply comparatively large quantities should they be called upon to do so. The refinery at Neodesha reported a total consumption of 85,215 barrels, 42 gallons each, of crude oil, from which they obtained 29,972 barrels, 50 gallons each, of refined oil, and 5880 barrels, 50 gallons each, of naphtha and gasoline, with a residue of 33,000 barrels, 42 gallons each, of fuel oil. According to this report, the average percentage production for the year in the refining processes is 41.87 per cent. refined oil and 8.21 per cent. gasoline and naphtha.

During the year considerable inquiry has been made by different parties connected with artificial gas factories in different parts of the state regarding the possibility of securing oil territory to supply their gas factories. One large company operating twelve or fifteen individual gas factories reported that they could consume nearly 500 barrels of crude oil per day if it were available, an amount more than double the average production for all our Kansas wells. Other companies which have written the University on the subject would consume a smaller

amount but in the aggregate would about half way equal the large company above mentioned. It is difficult to obtain thoroughly reliable estimates on this subject. Should the figures given by the representatives of the different companies be at all reliable, it is safe to say that private companies within the reach of the Kansas oil fields consume annually from two to three times the amount of oil now produced from our Kansas wells. The following table shows the annual oil output for 1899 and previous years:

TABLE X.

PRODUCTION OF PETROLEUM IN KANSAS FOR 1889 TO 1899, INCLUSIVE.

Figures for 1889 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.*	Barrels.	YEAR.	Barrels.	Price per barrel.	Value.
1889......	500	1894......	40,000	48 cts.	$19,200 00
1890......	1,200	1895	44,430	64 "	28,435 20
1891......	1,400	1896......	113,571	63 "	71,549 73
1892......	....	1897......	90,000	60 "	54,000 00
1893......	18,000	1898......	†88,000	$2 00	176,000 00
		1899......	85,215	75 cts.	52,167 00
		Totals..	468,657	....	$410,671 93

*Totals include estimated value, $9,320, of the product from 1889 to 1893, which was 21,100 barrels.

†Refined oil.

NATURAL GAS.

The apparent permanency of natural gas in Kansas, as indicated by the large consumption during the past year, is very gratifying. The strong wells at Iola supplying fuel to the zinc smelters have passed the test of more than a year without any appreciable decrease in pressure. The gas from none of these wells is measured, and therefore it is difficult to form even an approximate estimate of the amount consumed by the zinc smelters. During the year there was smelted by the use of natural gas as a fuel about 30,000 tons of metallic zinc. It is generally estimated that seven tons of coal are required to produce one ton of metallic zinc when coal is used for fuel. On this basis, our zinc smelters alone consumed natural gas at Iola, La Harpe and Cherryvale equaling 210,000 tons of coal. When we con-

sider that some of these large furnaces used gas from one well only for a period of six months or more and that such use did not sufficiently decrease the pressure in the pipe to attract the attention of the consumers, we must admit that the stability of such gas wells is very great. Unfortunately no measurements were made of the actual pressure given by the wells at the beginning of such consumption and at the expiration of any definite period, so that we cannot determine the actual decrease of pressure.

At the close of 1899 the zinc smelters in the state using natural gas had a capacity of more than 15,000 retorts, which should yield 180 tons of metallic zinc per day when in full operation. This would be equivalent to 1000 tons of coal per day, with a value at the coal-mines of from $500 to $600, supposing that slack coal were used. The total value of the gas used per year, with the present smelting capacity, therefore, if compared with the slack coal value at the coal-mines, will reach nearly $365,000.

There are also quite a number of large brick factories now in the gas fields which consume gas to an unknown extent. The brick-kilns use gas drawn directly from the wells, and no attempt is made to measure the amount consumed. There is a large brick factory at Coffeyville, three factories at Cherryvale, three at Iola, one of which was in operation throughout the year, and one at Paola. Besides these there are numerous mills of different kinds that consume gas instead of coal, and nearly a dozen cities are principally heated and lighted by natural gas.

The cash value of the total production of gas for the year, therefore, is very large, yet it is difficult to state in exact figures. For example, the retail price of gas for private consumption in different cities varies greatly. In one place it will be $1.50 a stove per month, and in another $2.50, while there is no apparent reason for any difference whatever, other fuels being as expensive in one place as in the other. Again, when estimating the value of gas used in manufacturing enterprises, such as brick kilns, smelting furnaces, and flouring mills, should we

compute the gas on the basis of the coal equivalent estimated at the selling price of coal at the factory, or should we use the selling price of slack coal at the mine where the smelters would be located had not natural gas been discovered? It is apparent from these considerations that any estimations of the actual value of the gas produced in the state is only relatively correct, and subject to great variations when made by different individuals. For this year the value is placed at $257,500. The folfowing table shows the value of the annual production of gas within the state, from 1889 to 1899, inclusive:

TABLE XI.

SHOWING VALUE OF NATURAL GAS PRODUCED IN KANSAS FROM 1889 TO 1899.

Figures for 1889 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.	Value.	YEAR.	Value.
1889	$15,873	1896	$124,750
1890	12,000	1897	155,500
1891	5,500	1898	188,840
1892	40,795	1899	257,500
1893	50,000		
1894	86,600	Total	$1,049,764
1895	112,400		

During the past year the gas fields have not been materially enlarged. The most pronounced success in new developments has been at Chanute. Years ago a few wells were drilled at this place, all of which proved failures, and therefore it was decided no gas could be found in that part of the country. This belief was so strong that during the latter part of 1897 gas was piped into Chanute from some miles to the west and introduced into a considerable proportion of the residences and business blocks of the city. During the past year a new impetus was given to the enterprise, and different wells were drilled, which resulted in the discovery of large bodies of natural gas, apparently equal to that found elsewhere in the state. This is a good illustration of the unreliability of our judgment on any particular section of the country when based upon the results obtained from only a few wells.

Year by year the previously outlined gas territory is becom-

ing more and more productive, with a greatly increasing number of flowing wells. The territorial limits are not extended, but the apparently barren areas within are gradually being reduced in number and size, yielding a strong indication that one is liable to find gas or oil at almost any place within the gas territory.

The experiences of the past year confirm the ideas previously expressed in these reports, that prospectors should expect to find their greatest bodies of gas or oil in the lower parts of the Cherokee shales. The shales lying above this horizon occasionally produce small flows, but there is not a single well of considerable importance in the state that does not draw its oil or gas from the lower half of the Cherokee shales. Experience likewise indicates the futility of searching for oil or gas below the Mississippian or Subcarboniferous limestone, and shows the absence of any considerable bodies of gas east of the outcropping of the Oswego limestone, although in a few places, such as Chetopa, enough gas has been found to pay well for the expense of drilling.

There is still no experimental reason for hoping that gas can be obtained in paying quantities by deep boring in the territory lying to the west of what has been outlined as the gas area. There is little to encourage the hope that deep boring will prove productive in the territory west of the eastern outcrop of the Burlingame limestone. This line extends northeast and southwest, from the eastern side of Brown county through the counties of Atchison, Jefferson, Shawnee, Osage, Lyon, Greenwood, Elk, and Chautauqua, to the south line of the state.

During the past year different parties living in Cherokee and Crawford counties have made repeated inquiries to ascertain whether or not it was advisable for them to prospect for natural gas. Even citizens of Galena have been led to hope that gas could be found by drilling into the Subcarboniferous rocks, provided a sufficient depth was reached, and this in face of the fact that not a single well anywhere in the lead and zinc mining region, no matter how deep, has ever produced the slightest indications of natural gas. In my report for 1898 a short discussion of this subject was given, in which the general condi-

tions obtaining in the oil and gas regions of the world were explained and conclusions drawn regarding the Kansas territory. On account of the wide-spread interest in this subject and the numerous inquiries the University is constantly receiving from different parts of the state, it is thought advisable to reproduce the discussions here.

*Geology of the Oil and Gas Fields.

"Thus far in our studies of the geology of Kansas almost nothing has been published regarding the geology of the oil and gas of the state. A few scattering papers by different geologists have appeared from time to time in the last ten years or more, but no systematic exposition of the general conditions has been published. The neglect of this department along this line is due principally to the fact that a special report is contemplated on the subject in the near future, for which a great deal of material has already been gathered. As it is somewhat uncertain when this report will be issued, a brief outline of the geology of the Kansas oil and gas fields will be included here.

"The general stratigraphy of eastern Kansas has been quite thoroughly studied and represented in the first part of Volume III, University Geological Survey Reports, from which report a few illustrations are here reproduced.

"The Coal Measures of Kansas, which are the oil and gas producing formations, are exposed over approximately 20,000 square miles in the eastern end of the state. At the base of the Coal Measures lies the Subcarboniferous, or Mississippian, exposed in the extreme southeastern corner of Cherokee county over an area of from thirty to thirty-five square miles. The upper surface of the Mississippian limestone dips to the west along the south line of the state a little more than twenty feet to the mile to as far west as Cherryvale, the westernmost point at which it has been reached by the drill. In a northwesterly direction the dip is considerably less, averaging from six to ten feet to the mile, depending upon the direction. North of the state line the inclination of the surface of the Mississippian

*Mineral Resources of Kansas for 1898, page 47.

seems to be less. A deep well was drilled last autumn at Madison, in the north part of Greenwood county, which was carried to the depth of 1896½ feet, reaching what was supposed to be the Mississippian limestone, but about which there may be some doubt. Other wells east of this point show that the general dip of the strata from Fort Scott westward to Emporia is not as great as that along the south line of the state. Still farther north the general inclination to the west and northwest is greater than in this middle territory.

Cherokee Shales.

"At the base of the Coal Measures lies a heavy bed of shales, the Cherokee shales, in which may be found a great deal of sandstone quite irregularly distributed. The Cherokee shales are exceedingly rich in organic matter, carrying the Weir-Pittsburg coal, the Fort Scott coal, the Leavenworth coal, the principal part of the coal mined in Labette county, and doubtless a great deal of other coal yet undiscovered. The greater part of these shales are black, some of them being exceedingly bituminous. The sandstone in the Cherokee shales is variable in quality as well as location, but generally it is moderately coarse, furnishing good reservoirs for oil, gas, and water.

"These Cherokee shales are known to extend northeast almost the entire width of the state, and probably do extend entirely across it and to a considerable distance beyond, both north and south. Their westward extension, as shown in plates I and II (reproduced from Volume III, University Geological Survey of Kansas), is known to reach as far as Madison. The deep well at Madison above referred to passed through 293 feet of them before striking the hard rock supposed to be the Mississippian. Other deep wells in many parts of the state show conclusively that this heavy shale bed reaches far to the west, such as the wells at Topeka and McFarland, each of which was carried into the Cherokee shales some distance, but neither of which entirely passed through them. The evidence of the wells which did go through them shows that in their westward extension they gradually become thinner. How far west they actually go is

entirely conjecture. Should the rate of diminishing thickness be maintained as exhibited from their outcroppings to Madison they will extend to the middle of the state or beyond.

"Our knowledge of the general character of the sandstones in the Cherokee shales is obtained by a study of the sandstone outcroppings in the eastern part of the state, and from the records of the many deep wells that are drilled in the oil and gas region. It is known that a sandstone bed is not continuous over a very wide area, but that any particular sandstone found in a given place may entirely change into shale in any direction within a few miles. Broadly speaking, therefore, the sandstones are lenticular deposits which apparently have no direct connection with each other, although they may be never so closely related in character and in the particular position in the shale beds which they occupy.

"This phase of the subject is a most important one in the practical development of the oil and gas fields. It makes prospecting much more uncertain, but at the same time renders it less possible for the well or set of wells to entirely exhaust a given area. If a well at Iola draws its gas from a certain sandstone horizon, the limited extent horizontally of this sandstone will necessarily limit the area from which the wells in question will be able to exhaust the supply of gas. If the particular sandstone beds of Iola do not extend to Cherryvale or Neodesha or Benedict, it is practically certain that there can be no direct relation between the gas of any two of the areas named.

"The Cherokee shales, or rather the sandstones within the Cherokee shales, furnish the gas at Chetopa, Coffeyville, Cherryvale, Neodesha, Benedict, Erie, Iola, and La Harpe, and all other points in that part of the state.

Formations above the Cherokee Shales.

"Above the Cherokee shales there is a succession of alternate beds of limestones and shales throughout the whole of the Coal Measure area, as illustrated in Plates I and II. Each shale bed has a considerable amount of sandstone within it, arranged practically the same as that already described for the Cherokee

shales. Many such sandstones have been oil or gas producers, and in some parts of the state, notably Osawatomie, Paola, and Ottawa, all the gas obtained has come from some of these higher sandstones.

"There is no essential difference yet known in the general relations between the sandstones and the shales of these upper horizons and the sandstones and shales below. When a well is started at any point far enough west to cause it to penetrate any of these limestones, it passes through successive horizons of limestone and shale. In general, the further north and west a well is located the more likely it will be to obtain gas from some of the upper horizons, and the more liable the sandstones within Cherokee shales are to be filled with salt water. By an examination of Plate III, a map showing the outcroppings of the more important limestones of the state, likewise reproduced from Volume III, one can readily determine the relative stratigraphic position of any point in the gas fields. If a well were started at Eureka, one might expect to pass through the shale beds lying between the Oread and Burlingame limestones, and all of the succeeding formations below. If a well were started at Fredonia, the first limestone reached would be the Iola. If one were started at Ottawa, in the valley of the Marais des Cygnes river, the first limestone reached would be the Garnett, unless perchance the mouth of the well happened to be below this particular horizon.

Depth at which Gas is Found.

"The depth at which gas is generally found in Kansas ranges from 500 feet to 1000 feet, although some wells are known beyond each of these extremes. It is readily apparent why gas must come from a considerable depth. If it is maintained at a pressure of 350 pounds to the square inch sufficient covering of rock strata must be over it to prevent its escape, a tendency that is very strong with so high a pressure. The superimposed strata must be sufficient in amount to have a weight greater than the gas pressure exerted on it; and it must be sufficiently impervious to prevent the leak which would occur were the

strata very porous. Fine grained clay shale is the best material known for holding gas down, on account of the closeness of grain, thereby causing all openings to be filled with the fine-grained clay particles. Were the cover rock of a porous nature, such as sandstone, or of a hard, firm nature, such as limestone or flint, readily rendered porous by fracture, the thickness of the covering would necessarily have to be much greater.

"It is an interesting fact that in all gas fields, with few if any exceptions, the overlying formations, whatever they may be, include one or more beds of fine grained, compact shales. Thus the Trenton limestone, which is the gas and oil producer of Indiana and western Ohio, is immediately overlaid by the fine grained Utica shales, which in turn are held down by the heavy beds of the Hudson river and Niagara limestones. In eastern Ohio and Pennsylvania likewise, wherever gas is found in any considerable quantity, a heavy bed of fine grained shale overlies the gas producing formations, serving as an impervious covering to prevent the gas from leaking.

"On the other hand, gas rarely is found at a very great depth. But few places have yet been discovered where gas could be obtained in any considerable quantity at a depth greater than 1800 feet. The reason for this is likewise apparent. As water is heavier than gas or oil, and as there is a constant supply of surface water which falls as rain water and penetrates to great depths, there is a tendency to fill all the underground cavities with this water. The gas can occupy the open spaces in the rock only when it has sufficiently strong pressure to prevent water from driving it out. This tendency of water to replace the gas is probably entirely dependent upon depth, while the capacity of gas to resist the encroachments of water is principally dependent upon the pressure under which the gas exists; therefore, the deeper the well the greater the gas pressure when gas is found, and likewise the stronger the probability of water being found instead of gas.

"The accidental condition of the water being salt or not probably has no bearing upon the question of gas supply. It

is generally true that deeply buried water is more or less mineralized, in proportion to the opportunity for drainage afforded the water bearing horizon. If a porous stratum comes to the surface in two or more places differing in altitude, so that the higher exposure may act as a gathering area for the rain water, the lower outcropping usually is notable as an area of springs. The constant passage of water from the higher to the lower has long ago washed the soluble saline ingredients out of the rock masses, and therefore this particular horizon will produce fresh water wherever reached at intermediate points, no matter how far below the surface the water may chance to be. This is well illustrated by the great Dakota sandstone formation of the great plains area. This sandstone comes to the surface along the eastern foot-hills of the Rocky mountains, and again appears at the surface throughout central Kansas, Nebraska and the Dakotas at an elevation of from 3000 to 4000 feet below the western exposures. The rain water falling near the mountains gradually works its way through sandstone beds, although at intermediate areas they lie in places more than 2000 feet beneath the surface. Wells drilled into this sandstone generally supply fresh water.

"But where the strata dip in one direction and the surface of the earth dips in the opposite direction, as in the case for eastern Kansas, as shown in Plates I and II, we have a porous horizon gathering rain water with no outlet. Such horizons, when penetrated further westward, produce water highly charged with salt and other soluble materials held by the formations through which the water has passed. The prospecting wells, therefore, when finding water as much as 600 or 1000 feet below the surface, generally find the same to be salt water, for the reasons given. That, perhaps, is all the essential relations between salt water and gas.

Area within which Gas may be Looked For.

"From the foregoing discussions it is readily seen that Cherokee county and the southeastern part of Crawford county failed to yield a supply of gas on account of the absence of a

sufficient mantle to protect the gas from escaping. Here the Cherokee shales, the great gas producing horizon, come to the surface. That these shales in this particular place do contain some gas is abundantly proved by the history of well digging and drilling throughout the area considered. A well driller of wide experience, one who has drilled hundreds of holes prospecting for coal in this particular territory, reported to the writer that fully one-third of all the wells drilled produced a little gas. Could a gas tight mantle be spread over that part of the state, even now, to remain sufficiently long, it is quite possible that gas would accumulate beneath it, producing a great gas area.

"Passing westward from the area named beyond the outcroppings of the Oswego and Pawnee limestones, as shown in Plate III, a mantle of from 200 to 500 feet in thickness is supplied, with a correspondingly large amount of gas, as is shown by the Chetopa and Oswego gas wells, which have a light pressure; those farther west, around Mound Valley, with a heavier pressure; and finally those beyond the Erie limestone, where the strong wells of Cherryvale, Independence, Coffeyville, Neodesha and Benedict are obtained. Passing still farther westward, until one has gone beyond the outcroppings of the Iola limestone, the mantle is correspondingly heavier, the gas leaks less, and the pressure at which the gas may be held is greater.

"As we pass westward, likewise, the essential conditions for retaining the gas in some of the upper shale bed horizons become greater. This is doubtless an important factor in the production of gas by the overlying shale beds, as witnessed at Paola, Osawatomie, Ottawa, and some of the points near the state line between Paola and Kansas City.

"The further consideration of this same series of conditions will show that by continuing still farther west beyond the eastern limits of the Burlingame limestone and into the Flint Hills region one need hardly expect to find a flow of gas from the Cherokee shales, even should the shales be found, simply because the Cherokee shales throughout the area indicated lie

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so deeply buried that the porous sandstone beds are entirely filled with water. Whether or not the overlying shale beds which pass to the westward, as shown in Plates I and II, are gas bearing can only be determined by prospecting.

"This department is frequently called upon to give advice regarding the advisability of prospecting for gas in the Flint Hills area, or further to the west. A number of different cities have contemplated putting in prospecting wells, with a view to municipal ownership of the wells. Private individuals have considered similar enterprises, and have asked for an opinion on the advisability of the matter. We have constantly advised that the probability of failure was greater than that of success for all points west of the outcroppings of the Burlingame limestone, as shown in Plate III. The reasons for such advice have already been given, namely: That the Cherokee shales, the greatest oil and gas producing horizon in the state, here lie so deep that probably water has entirely driven out both the oil and the gas, provided either was present; and, second, that the overlying shale beds, wherever they have been explored, have produced so small quantities that the risk of finding gas in those is correspondingly greater. Therefore there is a constantly decreasing degree of probability for the finding of either oil or gas as one moves westward.

"But within the area of the state bounded on the west by the outcroppings of the Burlingame limestone and on the east of the Oswego limestone gas may reasonably be expected. But developments thus far made show how uncertain the results of prospecting, yet each year opens up new fields and adds thereby a degree of probability to any part of the territory unexplored becoming productive when sufficiently developed."

V.—GYPSUM.

Gypsum Cement and Gypsum Cement Plasters.

THE total output of gypsum and its product for the year 1899 was the largest since 1895, and the largest of any year in our history, excepting 1894 and 1895. The sum total aggregates 61,103 tons, with an estimated value at the mills of $4.30 per ton, which amounts to $262,743. Of this, a little over 40,000 tons was made from gypsum-earth material, or about two-thirds of the total production of the state. The selling price of this plaster per ton seems to be a little greater than that made from gypsum rock.

There were three new factories started during the year. The American Cement Plaster Company, with head offices at Lawrence, Kan., began operating their plant at Mulvane about March 1 and continued uninterruptedly throughout the year, making a very successful run. Their plant consists of a two kettle furnace, with well arranged machinery, a side-track from the Santa Fe railway line a little over a mile in length, and other facilities for handling in the most economic manner the raw material and the manufactured product. This company also has a large mill and mines at Quanah, Tex., from where they send a large amount of material into the markets.

The Southern Kansas Cement Plaster Company, of Burns, Kan., began operating in February with a plant of one kettle capacity. The material they use seems to be first-class but it is situated some miles from the railway.

The Roman Cement Plaster Company, with mills at Springdale, on the Santa Fe railway, in the southwestern corner of Pratt county, has its mines at Sun City, in Barber county, so that it is necessary to haul the material some distance to the

mills. Years ago a mill was operated here for some time but remained idle for a number of years, and was started up early in 1899.

The Salina Cement Plaster Company, with head offices at Salina, operated their two mills, the one at Dillon, in southern Dickinson county, and the other at Longford, in southwestern Clay county.

The three mills at Blue Rapids were in operation throughout the year and did a very satisfactory business. These mills are supplied entirely with rock gypsum, from which they make plaster of Paris and different brands of finishing material to form the finishing white coat on walls; and also, by the use of retarders, they make cement plaster as well. They also made small sales of ground plaster to be used as a fertilizer, commonly known in the markets as land plaster.

One of the strange features of agriculture, as now carried on in the western Mississippi valley, is that this exceedingly cheap material is hardly used by any one as a fertilizer. It has been tested so thoroughly throughout the past 100 years that there can be no doubt of its value on many kinds of soils. Professor Grimsley discussed this subject very ably and elaborately from the historical, practical and theoretical standpoints, in chapter VII of Volume V of the Reports of the University Geological Survey of Kansas, to which chapter the reader is referred should he wish any further information on the subject. It might be stated here, however, that it seems to be pretty well established that the gypsum assists in the decomposition of insoluble silicates in the soil, thereby liberating potash which previously was held in an insoluble form, and that, therefore, the gypsum should be used on almost any soil deficient in potassium.

Occasionally, in the agricultural papers, some one asks for the address of companies selling land plaster, but as no company is advertising such material for sale the farmer who wishes to try its effect upon his farm is unable to secure the same, as it cannot readily be had on the markets. It would seem that our Kansas operators might do well for themselves and accommodate a comparatively large number of farmers were

they to insert advertisements in the leading agricultural journals, or in some other way let the farmers and horticulturists of the great Mississippi valley know where such material could be had, and at what price it could be obtained.

It is generally supposed by the operators that the so-called gypsum earth is unsuitable for fertilizing purposes. This is an entirely erroneous idea. The gypsum earth is already pulverized, as nature deposited it in small crystals or granules, so that no preparation whatever would be needed. In almost all places where factories are established on the gypsum-earth deposits large bodies of the gypsum exist containing a little too much clay to be of use for making plaster. The only objection to the presence of the clay in this low grade material, should it be used as a fertilizer, is that it would act as a dilutant; but its presence would in no other way be objectionable. The operators at any and all of the gypsum-earth deposits might well sell such material at very low figures, particularly when they are situated immediately on a railway, as the expense of loading would be at a minimum, and the material is such that otherwise it is of no value to them whatever. When the rock gypsum is used for fertilizing purposes it is quarried and ground ready for the calcining kettles, or possibly not quite so finely, and is then shipped and used in that form.

Year by year the use of the gypsum cement plasters is gradually increasing, so that the future demand is certain to remain good. Already it has almost entirely supplanted lime plaster for plastering walls in any and all kinds of buildings. Should the gypsum-earth supply become exhausted we can rest assured that the amount of rock gypsum in Kansas is sufficiently great to supply all demands for hundreds of years.

The following table shows the output and value of Kansas mines and mills for 1889 to 1899, inclusive.

TABLE XII.

SHOWING AMOUNT AND VALUE OF GYPSUM PRODUCED IN KANSAS FROM 1889 TO 1899.*

YEAR.	Output in tons (2000 pounds).	Average price per ton.	Value of output.
1889	17,332	$5 44	$94,235
1890	20,250	3 58	72,457
1891	40,217	4 01	161,322
1892	41,016	4 76	195,197
1893	43,631	4 16	181,599
1894	64,889	4 65	301,884
1895	72,947	3 74	272,531
1896	49,435	3 00	148,371
1897	50,045	5 05	252,811
1898	39,776	3 26	129,652
1899	61,103	4 30	262,743
Totals	500,641	....	$2,072,802

*Figures from 1889 to 1896, inclusive, are taken from the reports of the United States Geological Survey.

VI.—BUILDING AND OTHER STONE.

THE increased activity along many lines of business affected favorably the stone industry of Kansas during the year 1899. This is particularly true with reference to improvements of the road-beds by the different railroads in the state. The Kansas railroad companies are investing a large amount of capital in the improvement of their road-beds by way of making permanent stone culverts and by ballasting the through lines with stone or other suitable material. Also, the demand for building stone is greater than usual on account of the increased amount of building done in the state during the last year.

It is estimated that our railroads have used no less than 400,000 cubic yards of crushed stone for ballast. This has an average value of about 75 cents per yard, giving $300,000 for the value of the limestone crushed and used for ballast. It is further estimated that the railroads have consumed $200,000 of dimension stone in the construction of permanent stone culverts along lines which have been operated for years.

The sandstone quarries in southeastern Kansas which have furnished so much flagging stone for walks and curbings have not been operated quite so extensively as during previous years, but there has been a fair demand for such stone in different parts of the state. The heavy beds of sandstone in the vicinity of Neodesha and Thayer have likewise yielded considerable dimension stone to the trade.

In this series of reports for 1897, beginning on page 77, and again in the report for 1898, beginning on page 57, is a table giving the chemical analyses and a number of other properties of the principal Kansas stones, to which tables the reader is referred for information regarding the composition and physical properties of our Kansas building stone.

Lime making increased but little if any during the year; in fact, it is generally conceded that our Kansas limestones contain too great an amount of impurities to be of much value for making lime. Therefore it is no suprise that practically all the quicklime used in the state is shipped in from outside sources.

The following table gives a summary of the value of building stone quarried in the state for the last twelve years.

TABLE XIII.

SHOWING VALUE OF BUILDING STONE PRODUCED IN KANSAS FROM 1888 TO 1899.

Figures for 1890 to 1896, inclusive, are taken from the reports of the United States Geological Survey.

YEAR.	Sandstone.	Limestone.	Grand totals.
1880	$11,000	$131,570	$142,570
1888 *	1,000	144,000	145,570
1889	149,289	478,822	628,111
1890	149,289	478,822	628,111
1891	80,000	300,000	380,000
1892	70,000	310,000	380,000
1893	24,761	175,173	199,934
1894	30,265	241,039	271,304
1895	93,394	316,688	410,082
1896	18,804	158,112	176,916
1897	23,180	173,000	196,180
1898	25,000	180,000	205,000
1899	23,500	550,000	573,500
Totals	$699,472	$3,637,226	$4,337,278

* Reports for 1888 include only (for sandstone) the production from Ritchie; and (for limestone) the production from Winfield, Florence, Augusta, and Oketo.

VII.—CLAY PRODUCTS.

THE clay industries of the state were in a flourishing condition during the year 1899. Not only were all the plants kept going quite regularly but a number of new plants were constructed, particularly those at Cherryvale, Iola, and Lawrence. The Nesch plants, at Pittsburg, were partially destroyed by fire early in the year, but were reconstructed, so that only about two months' time was lost. The character of the goods manufactured was practically the same as that of previous years, namely, vitrified brick being the most prominent, common brick the next most abundant, and brick for making walks the third in quantity. A few factories also made drain-tile, and ornamental goods were made to a limited extent. The general prosperity which has existed throughout the state has made a great demand for almost all kinds of clay goods.

New Plants.

The Coffeyville Brick Company established a factory at Cherryvale, which was operated during a greater part of the year. It is located beside the Santa Fe railroad track, at the west end of the big mound about one mile south of Cherryuale, close to the other brick plant erected a year earlier. Gas wells were obtained at this place, which supply fuel for the brick kilns. The Cherryvale Vitrified Brick Company, with L. S. Skelton manager, erected a plant which began operations in October. It is located at the foot of the mound to the northwest of Cherryvale and near the St. Louis & San Francisco railroad line. One or more gas wells here supply gas for the kilns.

At Iola a new plant was erected by the Brush & Wadsworth Brick Company, which uses natural gas for fuel. The kilns are located south of town, at the foot of the little mound just east of the Santa Fe track.

The Lawrence Vitrified Brick and Tile Company erected a large plant at Lawrence, where coal will be used for fuel. The company was organized in June, with a fully paid up capital of $32,000. Under the general management of Mr. N. O. Stevens, who is secretary and treasurer for the company, it has had a prosperous beginning and has already sent brick to Kansas City and Topeka, and other near-by markets, in addition to supplying a large number for home consumption. Mr. Stevens kindly furnished the following statement regarding the installation of the plant:

"Immediately following the organization the company purchased its full line of machinery, which is as follows: Two 80-horse-power tubular boilers, one 125-horse-power engine, one 9-foot dry pan, one steel pug mill, one brick machine, capacity 40,000 brick per day of twelve hours, one automatic cutting table, one four-mold dry press, one ten-tunnel steam dryer, one tile machine, four down-draft kilns and one up-draft kiln. Work was begun on the plant early in July, 1899, and everything was in place and in full operation September 15, 1899."

The material used by all the new plants named is the Coal Measure shales. The plants at Cherryvale use the shale lying immediately under the Independence limestone, and find it very satisfactory. The two plants at Iola make brick from the shale beds immediately overlying the Iola limestone. The plant at Lawrence uses a bluish shale occupying a position near the middle of the Lawrence shales, which immediately underlie the Oread limestone. These shale beds are slightly arenaceous. The company has about fifteen acres of land underlaid with this bed of workable shale, which is from thirty to forty feet in thickness, so that they are assured of an abundance of material to work upon for the future.

In addition to the above mentioned new plants, a number of lesser ones have been constructed for temporary purposes here and there throughout the state, and a few large plants are building early in 1900.

The following Table XIV exhibits the character, amount and value of the clay products of the state for 1899:

TABLE XIV.

SHOWING AMOUNT, KIND AND VALUE OF KANSAS CLAY PRODUCTS FROM 1892 TO 1899.

Figures for 1893 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.	Common brick.			Dry-pressed brick. *a*			Re-pressed brick.			Vitrified brick.			Other brick.			Drain-tile, value.	Other clay products, value.	Total value.
	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.			
1892 *b*....	25,000	$5 75	$142,750	550	$7 50	$4,125	....	....	....	10,600	$8 00	$84,800	....	....	....	$6,000	$5,000	$242,675
1893 *c*....	20,000	5 75	115,000	1,000	7 50	7,500	....	....	....	8,000	8 00	64,000	....	....	....	5,000	4,500	196,000
1894 *d*....	24,518	5 75	141,042	....	....	....	....	....	....	7,948	7 21	57,310	....	....	....	8,048	12,175	218,575
1895......	20,756	5 87	121,892	3,730	6 91	25,275	....	....	....	7,902	7 87	62,190	....	....	....	4,090	33,700	247,647
1896......	19,694	5 59	110,254	1,541	6 13	9,440	....	....	....	16,934	7 39	125,293	....	....	....	4,400	10,700	260,087
1897......	19,548	5 33	104,257	1,948	5 26	10,241	....	....	....	18,378	7 13	132,222	....	....	....	7,600	11,000	265,320
1898......	23,157	6 34	146,765	5,050	5 55	28,050	1,525	$6 72	$10,250	26,182	7 28	190,735	731	$8 33	$6,088	8,592	150	390,630
1899......	25,750	6 25	160,937	6,225	6 00	37,350	3,275	7 25	25,381	26,478	7 25	181,943	....	....	....	9,275	844	415,730
Totals,	178,423	....	$1,042,897	19,044	....	$122,481	4,800	....	$35,631	122,419	....	$907,493	731	....	$6,088	$53,005	$78,069	$2,236,664

a. Previous to 1898 all pressed brick were figured together.
b. Only a partial report is obtainable for 1892.
c. Estimated.
d. For 1894 the common and pressed brick were figured together.

VIII.—HYDRAULIC CEMENT.

THE conditions of the hydraulic cement industry in Kansas during the year 1899 were practically unchanged from those of 1898. Fort Scott is the only place at which hydraulic cement is made. Here there are two plants that were in active operation through a greater part of the year; one owned by the Fort Scott Hydraulic Cement Company, and one owned by the C. A. Brockett Cement Company. The combined production for the year was 140,000 barrels, with a value of forty-five cents per barrel, giving a total value of $63,000. There was, therefore, a slight decrease in the production of hydraulic cement as compared with that of 1898. For some reason the market does not seem to demand very much hydraulic cement.

The following table shows the output in barrels, with value per barrel from 1888 to 1899, inclusive:

TABLE XV.

SHOWING AMOUNT AND VALUE OF HYDRAULIC CEMENT PRODUCED IN KANSAS FROM 1888 TO 1899, INCLUSIVE.

The figures from 1888 to 1896, inclusive, are based upon the reports given by the U. S. Geological Survey.

YEAR.	Barrels.	Price per barrel.	Value of output.
1888	40,000	75 cts.	$30,000
1889	150,000	70 "	105,000
1890	150,000	70 "	105,000
1891	140,000	69 "	97,440
1892 *	110 000	69 "	77,000
1893	60,000	35 "	21,000
1894	50,000	50 "	25,000
1895	140,000	40 "	56,000
1896	125,567	40 "	50,226
1897	160,000	40 "	64,000
1898	160,000	38 "	60,800
1899	140,000	45 "	63,000
Totals	1,425,567	....	....

* Includes Kansas City, Mo.

IX.—SALT.

THE salt industry of Kansas was prosperous during the year 1899. The total production was 2,172,000 barrels, an amount greater than ever before produced in one year. Prices also were better than they had been for three years, the average being thirty-five cents a barrel, making a total valuation of $760,200, exclusive of cooperage, or $1,183,740 with cooperage.

The market demand for evaporated salt continues much greater than for rock salt, although the demand for the latter remains about constant. Nearly all the evaporated salt was made at Hutchinson, while the rock salt came principally from Lyons and Kanopolis. The old mines at Kingman have recently been reopened and are now supplying salt to the general markets. The factory at Solomon using the solar process was fairly active during the year, producing about the usual tonnage.

At Hutchinson the following companies are making evaporated salt, the Kansas Salt Company having consolidated with the Hutchinson Salt Company during the year: Hutchinson-Kansas Salt Company, Hutchinson Packing Company, Barton Salt Company, Jay-Morton Salt Company, and the Union Salt and Ice Company.

The following table shows the total state output for the year and also since the salt industry first began in the state.

TABLE XVI.

SHOWING AMOUNT AND VALUE OF KANSAS SALT PRODUCTION FROM 1888 TO 1899, INCLUSIVE.

Statistics for 1888 to 1896, inclusive, from United States Geological Survey reports.

Year.	Barrels.	Average price.	Value.
1888	155,000	$1.219	$189,000 00
1889	450,000	.45	202,500 00
1890	882,666	.45	397,199 00
1891	855,536	.357	304,775 00
1892	1,480,100	.523	773,989 00
1893	1,277,180	.369	471,543 00
1894	1,382,409	.383	529,392 00
1895	1,341,617	.36	483,701 00
1896	1,347,793	.31	519,475 00
1897	1,224,980	.34	417,626 94
1898	1,810,809	.27	489,454 23
1899*	2,172,000	.35	760,200 00
Totals	14,380,090	....	$5,538,855 17

*Cooperage in 1899 is reported at about twenty-six cents a barrel, and in other years at proportional rates, which should be added to above totals to give a correct idea of the magnitude of the salt industry.

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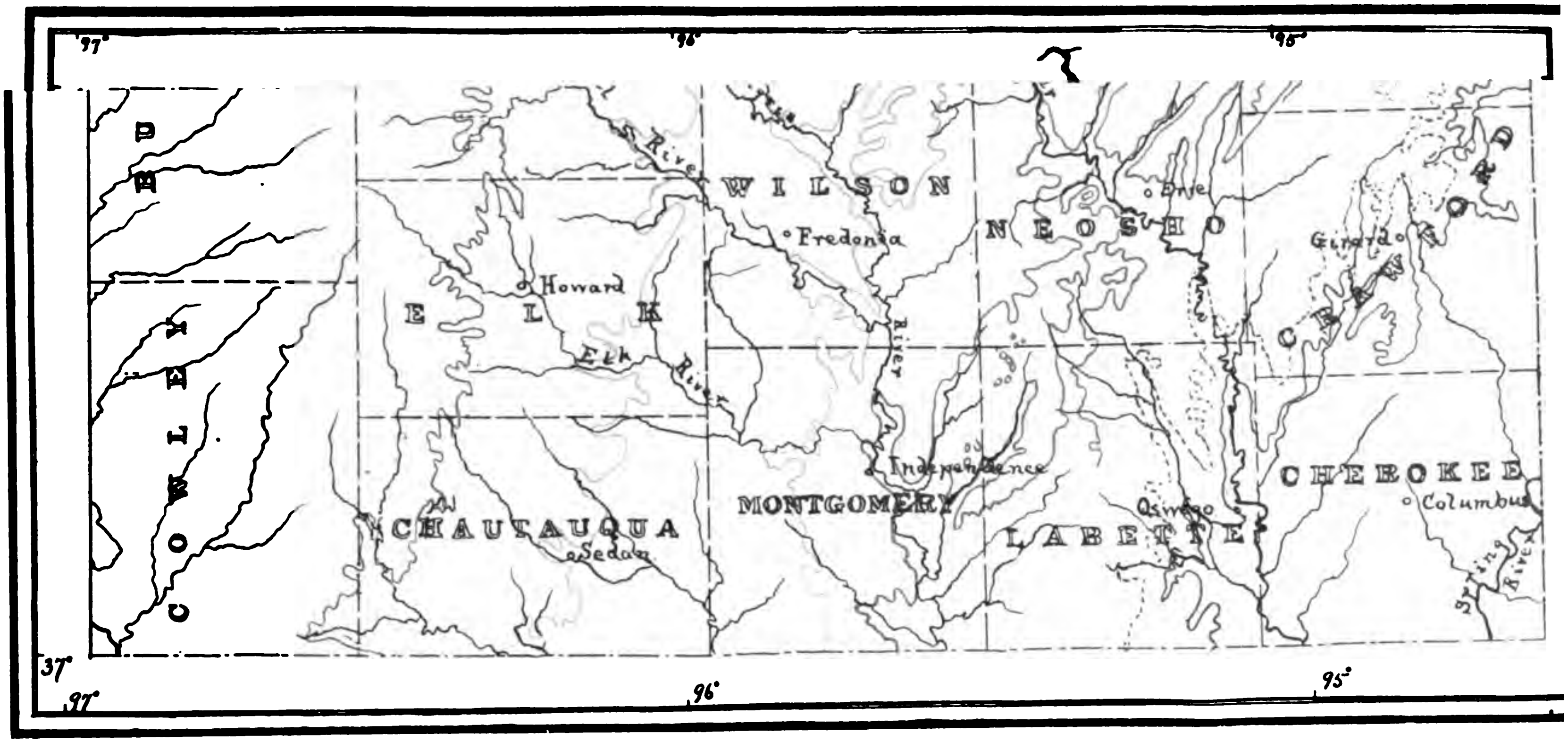

MAP OF LIMESTONE OUTCROPPINGS.

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Oread Limestones.
Garnett Limestones.
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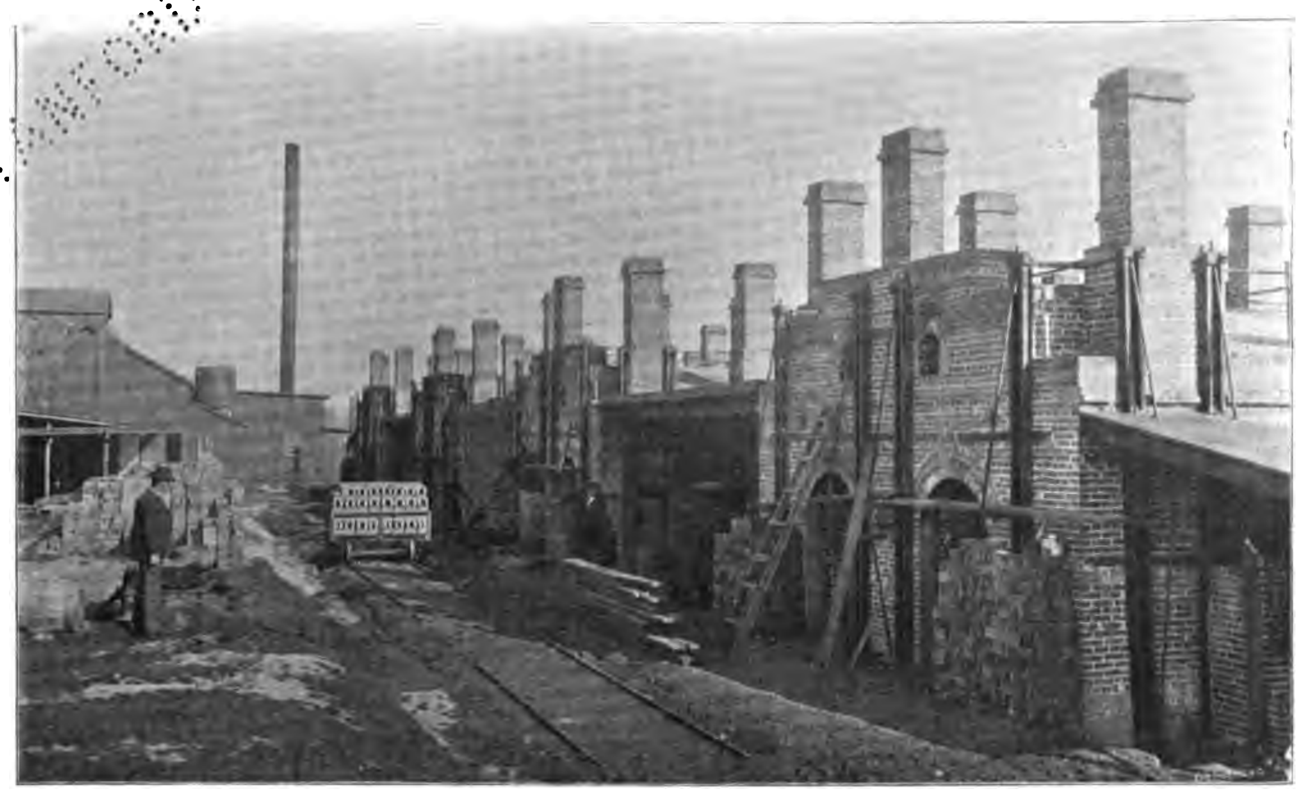
Erie Limestones.
Pawnee Limestone.
Oswego Limestones.



Interior View of Lawrence Brick Plant.

Mineral Resources of Kansas.

1900 and 1901.

Gold and Silver.
Lead and Zinc.
Coal.
Oil and Gas.
Clay Products.
Gypsum
and Gypsum Cement Plasters.
Hydraulic and Portland Cements.
Building and Other Stone.
Salt.

THE UNIVERSITY GEOLOGICAL SURVEY OF KANSAS.

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ANNUAL BULLETIN ON THE MINERAL RESOURCES OF KANSAS, FOR 1900 and 1901,

INCLUDING A REPORT UPON GOLD AND SILVER, LEAD AND ZINC, COAL, OIL, GAS, CLAY PRODUCTS, GYPSUM, HYDRAULIC AND PORTLAND CEMENTS, BUILDING STONE, AND SALT.

By ERASMUS HAWORTH,

Department of Physical Geology and Mineralogy, University of Kansas.

LAWRENCE, KANSAS:

MAY 1902.

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CHANCELLOR UNIVERSITY OF KANSAS,
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LETTER OF TRANSMITTAL.

Hon. W. C. Spangler, Vice-chancellor of the University of Kansas:

DEAR SIR—I have the honor to submit to you herewith my annual report on the mineral resources of Kansas for the years 1900 and 1901, combined in one, which will constitute the fourth annual bulletin of this series. It affords me pleasure to state that the mining and metallurgical interests of Kansas during the past two years were in a prosperous condition, yielding a great increase to the productive wealth of our state.

Yours most respectfully,

ERASMUS HAWORTH.

DEPARTMENT OF PHYSICAL GEOLOGY AND MINERALOGY,
UNIVERSITY OF KANSAS, MAY, 1902.

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INTRODUCTION.

THE mining and metallurgical operations of the state, during the years 1900 and 1901, were conducted along the same lines they previously followed. No strikingly important developments were made at any time during the years; neither were there any remarkable variations in production compared with other years.

An important item of interest is the closing down of the refinery at Argentine, during 1901, indicating that possibly the American Smelting and Refining Company would ultimately abandon the plant. The included tables for 1900 and 1901 fail to show the production of the Argentine plant, the owners positively refusing to give data concerning its output.

The zinc smelting industry practically has been entirely removed to the gas regions, the only coal smelters in operation being run but a short time in 1900, and the Girard smelters being the only ones operated in 1901. It is currently reported that gas smelters can produce spelter cheaper than coal smelters, thus making it impossible to operate the latter. However, it may be noticed that coal smelters at Nevada, Mo., have been in operation almost continuously, as also have those of Illinois. Some light may be thrown on this subject by a careful examination of table VII, which gives the ratio between prices of zinc in the ore and after it is smelted. It will be noticed by a perusal of this table that the margin for expenses and profits is the smallest for any year yet given. The ratio of price per ton of spelter in the ore and at New York after smelting is 1 : 2.89 for 1900, and 1 : 2.9 for 1901, which is the lowest yet recorded. Also, the actual margin between the selling price of a ton of spelter and the purchasing price of the same in the form of sixty-per-cent. ore is \$37.33 for 1900 and \$34.92 for 1901, which,

again, is the lowest yet known. It is quite evident from these facts that the ore-buyers have paid a higher price for ore relatively to the selling price of spelter than ever before has been done.

The output of coal for 1900 is the greatest, both in tonnage and value, ever yet recorded for the state, the yield being the magnificent sum of more than five and one-half million dollars in value, with the average price per ton at the mine being but $1.25. For 1901 the results are even better. This shows that the coal-mining business is in a prosperous and healthy condition, and that our mines have a capacity sufficient to meet the extraordinary demands placed upon them.

The production of oil for 1900 was not as great as that of previous years, neither was the output of the refinery at Neodesha quite as great as for the year 1899. On the other hand, the production of natural gas was far in advance of previous years. The extraordinary demands for gas in the rapidly increasing manufacturing enterprises now located in the gas-fields is the principal cause of this increase. In addition, gas has been piped into some of the towns which previously were not consumers, and heavy flows of gas have been found in new localities. The difficulty in the way of estimating the actual value of the gas makes different estimates vary greatly. The manufacturing enterprises using gas during the year could not have been kept in operation without a consumption of more than one million dollars' worth of coal. In 1901 the production of oil increased to 169,197 barrels, on account of the large sales from Chanute. The consumption of gas likewise greatly increased. The large manufacturing interests increased their demands greatly, while domestic consumption was the largest ever known.

An industry which has responded promptly and extensively to the new conditions is the manufacture of brick and other clay goods. There has been an unusual demand for all kinds of brick, which has been met quite largely by the brick factories in the gas-fields. In addition to this, the Union Pacific Railway Company has burned a large amount of clay or "gumbo"

Shale Clay-pit at Yard of Kansas Vitrified Brick Company's Brick Plant, Chanute, showing Cross-fractures in Shale.

for ballast, making the value of this one commodity surpass the total value of clay products of the state only a few years ago.

The large Portland cement factory at Iola has done a good business, but has been unable to fill all orders received. As a result, the plant will soon be enlarged to about double its present capacity. It is also reported that another large Portland cement factory will soon be built in the vicinity of Independence.

Other new industries will soon be established in the state. A window-glass factory has already been located at Coffeyville. Two new brick plants are building at Sycamore, a station on the Missouri Pacific railway, between Neodesha and Independence. Others are springing up in different places, adding greatly to the state's industries.

Tables I and II show in a general way the total mineral and metallurgical production for 1900 and 1901.

TABLE I.

SHOWING VALUE OF EACH OF THE MINERAL PRODUCTS OF KANSAS FOR 1900, AND SINCE INDUSTRY BEGAN.

Name of Product.	Amount for 1900.	Value per unit.	Value for 1900.	Grand total of production since industry began.
NON-METALLIC PRODUCTS.				
Coal . . . . tons	4,269,716	$1 28	$5,500,709 58	$65,710,598 69
Coke	37,500	2 50	93,750 00	. . . .
Salt, without cooperage . . . . bbls.	1,679,956	65	1,091,971 40	6,630,826 57
Cooperage . . . . bbls.	839,978	25	209,994 50	. . . .
Clay products	. . . .	. . . .	829,732 00	3,066,396 00
Gypsum cement plaster . . . . tons	56,112	4 35	244,611 00	2,317,412 00
Stone, building (estimated)	. . . .	. . . .	487,616 00	4,834,894 00
Natural gas	. . . .	. . . .	602,596 00	1,652,360 00
Oil, crude . . . . bbls.	91,294	80	79,035 20	480,387 13
Oil, refined, including gasoline and fuel oil	95,400	2 00	190,800 00	190,800 00
Hydraulic cement . . . . bbls.	127,339	40	50,333 00	834,799 00
Portland cement (estimated) . . . . bbls.	325,000	2 00	650,000 00	650,000 00
Lime (estimated)	. . . .	. . . .	65,000 00	1,445,000 00
Sand (estimated)	. . . .	. . . .	100,000 00	550,000 00
METALLIC PRODUCTS.				
Zinc ore, 46,513.50 tons, worth $1,248,432.33, yielding metallic zinc . . . . tons	23,256.75	87 80	2,041,942 65	45,811,987 95
Lead ore, 4,938.44 tons, worth $140,995.87, yielding metallic lead . . . . tons	3,456.90	90 78	313,817 38	
SMELTING PRODUCTS.				
Zinc smelting . . . . tons	57,876	87 80	5,028,832 80	40,754,534 83
Lead smelting . . . . tons	1,579	90 78	143,341 62	5,463,618 63
Totals	. . . .	. . . .	$17,724,083 13	$180,393,614 80

TABLE II.

SHOWING VALUE OF EACH OF THE MINERAL PRODUCTS OF KANSAS FOR 1901, AND SINCE INDUSTRY BEGAN.

NAME OF PRODUCT.	Amount for 1901.	Value per unit.	Value for 1901.	Grand total of production since industry began.
NON-METALLIC PRODUCTS.				
Coal . . . . tons	4,793,374	$1 30	$6,231,386 00	$71,941,984 69
Coke	42,750	2 50	106,875 00	873,375 00
Salt, without cooperage . . . . bbls.	1,271,015	60	762,609 00	7,393,435 57
Cooperage . . . . bbls.	635,507	25	158,877 00	158,877 00
Clay products	. . . .	. . . .	927,808 00	3,994,204 00
Gypsum cement plaster . . . . tons	49,217	4 25	209,172 00	2,526,585 00
Stone, building (estimated) . . . . cu. yds.	. . . .	. . . .	529,157 00	5,354,051 00
Natural gas	. . . .	. . . .	768,506 00	2,420,866 00
Oil, crude . . . . bbls.	169,197	80	135,357 60	615,744 73
Oil, refined, including gasoline and fuel oil	112,500	2 00	225,000 00	
Hydraulic cement . . . . bbls.	131,372	43	56,490 00	891,289 00
Portland cement (estimated) . . . . bbls.	750,000	2 00	1,500,000 00	2,150,000 00
Lime (estimated)	. . . .	. . . .	65,000 00	1,510,000 00
Sand (estimated)	. . . .	. . . .	100,000 00	650,000 00
METALLIC PRODUCTS.				
Zinc ore, 33,974.82 tons, worth $797,844.36, yielding metallic zinc . . . . tons	16,987.41	81 50	1,384,473 90	47,514,550 68
Lead ore, 5,238.19 tons, worth $245,880.64, yielding metallic lead . . . . tons	3,666.73	86 75	318,088 83	
SMELTING PRODUCTS.				
Zinc smelting . . . . tons	81,542.30	81 50	6,645,697 45	47,351,332 28
Lead smelting . . . . tons	1,137	86 75	98,634 75	5,562,253 38
Totals	. . . .	. . . .	$20,223,132 53	$200,908,548 33

I.—GOLD AND SILVER.

Gold and Silver Ores.

NO gold or silver ores from Kansas were sent into the markets during the years of 1900 and 1901. The agitation regarding gold in the Cretaceous shales of Ellis and Trego counties still continues with unabated interest. The reported gold discovery in the vicinity of Galena, Kan., mentioned in our report for 1899 (p. 12), has proved to be a failure. The development work did not progress far, nor did the excitement last long. As these are the only places in the state from which gold and silver are reported, nothing need be added regarding the production of gold and silver ores during the years 1900 and 1901.

Gold and Silver Smelting.

The gold and silver smelting and refining works at Argentine have passed into the hands of the American Smelting and Refining Company. The secretary of this company declined to make a report for publication regarding the business done at the refinery. Near the close of the year 1900, rumors were current to the effect that the refinery was to be closed down, a condition realized during 1901. With the absence of any specific report from the company, the customary tables showing the output of this large establishment must be omitted. Table IV in our 1899 report shows that during the period of operation up to the close of that year a sum total of over 147 million dollars' business was accomplished. It will be a severe blow to Kansas metallurgical interests should the refinery be closed permanently. At this writing, rumors are current to the effect that a similar refinery is to be built at Chanute, but nothing definite is made public.

II.—LEAD AND ZINC.

THE years 1900 and 1901 witnessed a considerable falling off in the production of both lead ores and zinc ores, compared with 1899. Table III shows the monthly output and price of zinc ore and lead ore for 1900; table IV, the same for 1901; while table V shows the production and price of both ores produced in Kansas, 1886 to 1901, inclusive. This falling off seems to be due principally to the rapid decline in prices of ore. No new developments of any considerable importance have been made, no new territory opened which has proved especially remarkable, and no new impetus to the industry of any character has been witnessed during the two years.

LEAD-ORE AND ZINC-ORE MINING.

Galena District.

The geography of the mining operations during the past two years in the Galena district was essentially the same as that during 1899. Some outlying camps were entirely abandoned, others were partially abandoned, while still others were probably more productive than at any other time. In the immediate vicinity of Galena the Gracie Clarke mines, a few miles north of town, were abandoned; some of the mills in Cooper Hollow were in operation only a part of the time; perhaps half the mills to the far south, in the vicinity of the old Stanley diggings, were largely idle; while in general, throughout the richer mining territory, a portion of the mills were shut down a part or all of the time. In some localities, however, there was an unusual activity, with a correspondingly increased production.

Lead and Zinc Ores in Other Parts of the State.

The only place in the state outside of the Galena district where mining for lead and zinc ores was prosecuted was near Pleasanton, as first mentioned in our report for 1898, page 23. Prospecting was continued here in the shales, and it is reported that a few small shipments of lead ore were made. As far as developments have shown there is an exceedingly small area of productive ground, shafts and drill holes only a few feet away having failed to yield marketable values. The ores here are in the shale, occupying little openings which seem to be connected with a seam or fissure of no great extent. Galena is more abundant than blende, although some fair specimens of the latter have been produced.

The different places here and there over eastern Kansas which have produced small traces of lead ore or zinc ore have failed to attract sufficient interest to cause very much prospecting. It probably is well within limits to state that traces of lead ore or zinc ore have been found in more than a hundred different places in the eastern fourth of the state. For example, at the Donald coal-mine at Atchison an examination of the debris revealed small quantities of both galena and blende, particularly the latter, occurring in the rich bituminous shales in contact with the coal. Zinc blende has been reported from more than a dozen counties, and in some instances from nearly a dozen places in one county, usually filling fissures in calcareous concretions embedded in the Coal Measure shales.

TABLE III.

SHOWING AMOUNT AND VALUE OF ZINC ORE AND LEAD ORE IN THE GALENA AREA
compared with amount and value of same ores for the whole Galena-Joplin area, 1900.
Data gathered from reports in *Engineering and Mining Journal*.

MONTH.	Product and value of Kansas area in 1900.					Product and value in Kansas and Missouri area in 1900.					Per cent. Kansas production of whole area, 1900.	
	Zinc ore. In tons (2000 lbs.) and dollars.		Lead ore. In tons (2000 lbs.) and dollars.		Total value.	Zinc ore. In tons (2000 lbs.) and dollars.		Lead ore. In tons (2000 lbs.) and dollars.		Total value.		
	Product.	Price.	Product.	Price.		Product.	Price.	Product.	Price.		Zinc ore.	Lead ore.
January	4,607.97	$35 12½	507.72	$55 88	$175,742	19,412.75	$35 12½	2,371.28	$55 88	$733,745	23.73	21.41
February	4,094.31	34 50	379.28	55 24	147,838	19,244.87	34 50	1,875.43	55 24	668,350	20.75	22.20
March	5,183.56	32 60	612.14	54 70	177,931	23,697.64	32 60	2,454.99	54 70	798,751	21.87	24.93
April	5,297.44	32 87½	645.27	54 00	180,291	27,229.22	32 87½	3,207.76	54 00	874,780	19.45	20.11
May	4,065.79	30 62½	552.99	47 50	139,603	23,595.43	30 62½	2,765.59	47 50	778,701	17.23	19.99
June	3,250.94	27 80	320.41	43 70	103,125	19,773.45	27 80	2,247.12	43 70	697,925	16.44	14.25
July	3,003.74	27 50	236.63	44 12	83,721	17,359.02	27 50	1,923.91	44 12	499,265	17.24	12.27
August	2,989.07	28 37½	346.28	46 50	82,454	20,000.74	28 37½	2,116.92	46 50	623,431	14.65	16.35
September	3,887.28	27 70	432.61	46 00	99,477	20,871.18	27 70	2,429.47	46 00	626,938	18.62	17.39
October	3,212.95	28 50	282.60	46 00	90,091	20,643.77	28 50	2,291.84	46 00	604,043	15.61	12.33
November	3,417.66	28 87½	268.78	46 00	94,268	20,752.58	28 87½	2,597.34	46 00	626,791	16.47	18.00
December	3,550.64	28 95	363.72	46 00	104,692	20,240.91	28 95	2,924.71	46 00	647,819	17.54	12.43
Totals and averages,	46,513.50	$30 28	4,938.44	$48 80	$1,479,233	252,821.56	$30 28	29,206.37	$48 80	$8,180,539	18.30	17.22

TABLE IV.

SHOWING AMOUNT AND VALUE OF ZINC ORE AND LEAD ORE IN THE GALENA AREA compared with amount and value of same ores for the whole Galena-Joplin area, 1901.

Data gathered from reports in *Engineering and Mining Journal.*

MONTH.	Product and value of Kansas area in 1901.					Product and value of Kansas and Missouri area in 1901.					Per cent. Kansas production of whole area, 1901.	
	Zinc ore. In tons (2000 lbs.) and dollars.		Lead ore. In tons (2000 lbs.) and dollars.		Total value.	Zinc ore. In tons (2000 lbs.) and dollars.		Lead ore. In tons (2000 lbs.) and dollars.		Total value.	Zinc ore.	Lead ore.
	Product.	Price.	Product.	Price.		Product.	Price.	Product.	Price.			
January	2,193.08	$27 00	422.34	$55 66	$65,759	18,615.15	$27 00	2,343.40	$55 66	$541,509	11.77	18.04
February	2,671.49	27 25	440.79	45 00	81,750	18,397.70	27 25	2,492.99	45 00	537,216	14.52	17.68
March	3,654.49	27 20	761.14	46 30	123,463	25,759.68	27 20	3,424.54	46 30	777,146	14.18	22.22
April	2,751.04	28 38	364.13	45 62	82,130	20,301.04	28 38	2,266.64	45 62	606,087	13.55	15.62
May	3,402.04	28 38	551.71	46 00	104,302	22,917.13	28 38	2,883.82	46 00	692,194	14.80	19.13
June	3,023.80	27 80	509.71	47 30	93,572	23,129.98	27 80	3,112.84	47 30	710,550	13.07	16.37
July	2,805.49	27 65	416.52	47 26	82,894	20,293.25	27 65	3,235.20	47 26	638,759	13.82	12.87
August	2,977.24	26 87	365.69	47 00	95,000	20,054.23	26 87	3,094.27	47 00	626,780	14.84	11.81
September	2,297.87	26 25	310.60	46 12	66,247	20,642.09	26 25	2,768.64	46 12	600,010	11.13	11.21
October	2,946.83	28 00	393.02	46 50	74,696	22,406.58	28 00	3,409.74	46 50	735,389	13.15	11.52
November	2,894.92	29 00	424.82	46 50	94,788	22,902.44	29 00	3,453.01	46 50	755,822	12.64	10.12
December	2,356.55	31 62	287.17	44 00	79,124	18,649.28	31 62	2,440.23	44 00	624,402	12.68	11.57
Totals and averages,	33,974.82	$27 95	5,238.19	$46 94	1,043,725	254,068.55	$27 95	34,925.36	$46 94	$7,845,814	13.34	14.92

Vertical Cross-fractures in Shale at Clay-pit near Brick-yard of Kansas Vitrified Brick Company's Plant, Chanute.

TABLE V.

SHOWING OUTPUT OF ZINC AND LEAD ORES, GALENA DISTRICT, KANSAS.

From January 1, 1886, to December 31, 1901, inclusive. Data since 1895 from the *Engineering and Mining Journal*; others from Mr. Russell Elliott, Galena.

YEAR.	ZINC ORE.			LEAD ORE.			Total value of output.
	Tons (2000 lbs.)	Average price per ton.	Value.	Tons (2000 lbs.)	Average price per ton.	Value.	
1886 ..	31,768.00	$18 50	$587,708 00	2,962.14	$59 00	$174,766 38	$762,474 38
1887 ..	32,795.00	19 00	623,105 00	3,073.19	52 50	161,499 98	784,604 98
1888 ..	33,391.00	21 00	701,211 00	2,624.00	31 00	81,344 00	782,555 00
1889 ..	32,950.00	24 00	790,800 00	3,992.50	46 00	183,655 00	974,455 00
1890 ..	21,675.00	23 00	498,525 00	4,173.96	42 28	176,176 28	674,701 28
1891 ..	20,641.00	21 51	454,102 00	3,602.21	50 32	182,271 83	636,373 83
1892 ..	23,811.00	20 00	476,237 78	7,188.17	42 00	301,903 14	778,140 92
1893 ..	25,028.00	18 85	471,789 00	5,139.59	38 00	195,314 42	667,103 42
1894 ..	28,670.00	17 10	490,257 00	5,817.49	33 64	195,794 66	686,051 66
1895 ..	41,232.00	19 68	812,792 00	12,537.64	38 56	482,548 75	1,295,340 75
1896 ..	62,232.00	22 51	1,401,307 83	14,061.58	32 04	450,529 90	1,851,837 73
1897 ..	59,451.00	25 17	1,492,663 04	15,184.68	50 20	762,469 96	2,255,133 00
1898 ..	74,852.00	26 64	1,994,230 55	7,918.28	42 04	352,798 45	2,347,029 00
1899 ..	64,708.48	38 54	2,313,831 00	6,723.40	52 62	354,311 00	2,668,142 00
1900 ..	46,501.35	30 28	1,238,237 13	4.938.44	48 80	240,995 87	1,479,233 00
1901 ..	33,977.80	27 95	797,844 37	5,238.19	46 94	245,880 63	1,043,725 00
Totals for 16 years ..	633,683.63	$373 73	$15,144,640 70	105,178.46	$705 94	$4,542,260 25	$19,686,900 95

Prices of Lead and Zinc Ores.

Prices for ore during the past two years were considerably below those paid during 1899, but still were about the average for the past sixteen years. A rapid decline from the prices of 1899 began near the close of that year, and continued throughout the first half of 1900. In January the best grade of 60-per-cent. zinc ore was bringing from $33 to $37 per ton, with an average for the month of a little over $35. This dropped in February to $34, in March and April to $32, in May to $30, June and July to $27, with a slight increase in August, then again to $27 in September, and remained at from $28 to $28.75 throughout the remainder of the year, giving an average price of $30.28 for 60-per-cent. ore for the entire year. Compared with prices of zinc ore for the preceding year, we find that the average is about $8 per ton less. Prices remained almost constant during 1901, but increased perceptibly near the close, with an average for the year of $27.95 for 60-per-cent. ore.

The lead market during the last biennium was tolerably constant, with an average of $48.80 per ton for 1900 and $46.94 for 1901.

Table VI has been prepared to show the variation in the prices of zinc ores and lead ores during the last four years, and also of the metals themselves, New York prices being quoted. This period includes that of the wonderful rise in the price of ore, and hence the period of greatest activity in the mining district. It will be seen that throughout April and May, 1899, zinc ore reached the highest price, averaging $51.50 for April and $50.50 for May. The highest price paid for the year was $55 per ton, for some extra choice ore in the vicinity of Joplin. Going back to the year 1898, it will be noticed that at the beginning of the year zinc ore was down to $23.25 for the average, dropping to $22.50 in May, then to $28 in June, dropping a little in July and August, and rising again in September, then dropping to $24.40 in October, and closing in December, 1898, at a little over $36.

TABLE VI.

SHOWING COMPARATIVE VALUES PER TON (2000 LBS.) OF ORES IN JOPLIN AREA AND METALLIC PRODUCTS IN NEW YORK.

Month.	Zinc.								Lead.							
	1898.		1899.		1900.		1901.		1898.		1899.		1900.		1901.	
	Ore.	Spelter.	Ore.	Spelter.	Ore.	Spelter.	Ore.	Spelter.	Ore.	Pig lead.	Ore.	Pig lead.	Ore.	Pig lead.	Ore.	Pig lead.
January	$23 25	$79 20	$40 25	$106 80	$35 13	$93 00	$27 00	$82 60	$44 00	$73 00	$47 88	$83 60	$55 50	$93 60	$55 66	$87 00
February	22 62	80 80	43 37	125 60	34 50	92 80	27 25	80 20	43 50	74 20	53 00	89 80	55 38	93 50	45 00	87 00
March	22 50	90 00	43 40	126 20	32 60	92 00	27 20	78 20	46 24	74 40	51 60	87 40	54 90	93 50	46 30	87 00
April	27 30	85 20	51 50	133 40	32 88	94 20	28 38	79 60	43 20	72 60	44 50	86 20	54 12	93 50	45 62	87 00
May	25 50	85 40	50 50	137 60	30 63	90 60	28 38	80 80	43 50	72 80	52 00	88 80	51 50	83 62	46 00	87 00
June	28 00	95 40	45 50	119 60	27 80	85 80	27 80	79 80	45 74	76 40	52 00	88 60	43 10	78 02	47 30	87 00
July	27 90	93 20	44 20	116 40	27 50	85 60	26 65	79 00	45 20	79 00	53 80	90 40	45 24	80 60	47 26	87 00
August	27 00	91 60	45 00	113 00	28 38	83 40	26 87	79 80	46 12	80 00	54 50	91 40	46 12	85 00	47 00	87 00
September	30 50	93 40	43 75	110 00	27 70	82 20	26 25	81 60	47 00	79 80	54 00	91 60	45 80	87 00	46 12	87 00
October	24 40	99 60	43 50	106 40	28 50	83 00	28 00	84 60	46 90	75 60	53 80	91 50	46 00	87 00	46 50	87 00
November	34 75	105 80	35 00	92 80	28 88	85 80	29 00	85 80	42 16	74 00	54 40	91 50	46 00	87 00	46 50	87 00
December	36 10	102 00	36 00	93 20	28 95	85 00	31 62	85 75	40 00	75 20	54 00	92 80	46 00	87 00	44 00	84 02
Averages	$27 64	$91 40	$38 54	$115 00	$30 28	$87 80	$27 95	$81 50	$44 85	$75 60	$52 62	$89 40	$49 14	$90 78	$46 94	$86 75

TABLE VII.

SHOWING PRICE PER TON OF ZINC BLENDE AT GALENA-JOPLIN

From 1886 to 1901, inclusive, and price per ton of metallic zinc in New York, with ratio between the two; also, price per ton of metallic zinc in sixty-per-cent. zinc ore and difference between this and New York price.

YEAR.	Price per ton of zinc blende in Galena-Joplin. (2,000 lbs.)	Price per ton of metallic zinc in New York. (2000 lbs.)	Ratio between price of zinc blende and metallic zinc.	Price per ton of metallic zinc in 60-per-cent. ore. (2000 lbs.)	Difference between price per ton of zinc in 60-per-cent. ore and New York price.
1886.........	$18 50	$87 90	1:4.69	$30 83	$57 07
1887.........	19 00	92 80	1:4.88	31 67	61 13
1888.........	21 00	98 34	1:4.68	35 00	63 34
1889.........	24 00	100 20	1:4.17	40 00	60 20
1890.........	23 00	108 75	1:4.72	38 33	70 42
1891.........	21 51	108 82	1:5.05	35 85	72 97
1892.........	20 00	89 78	1:4.48	33 33	56 45
1893.........	18 85	80 37½	1:4.28	31 42	48 95
1894.........	17 10	70 43	1:4.09	28 17	41 26
1895.........	19 68	71 04	1:3.60	32 80	38 24
1896.........	22 51	79 70	1:3.54	37 45	42 25
1897.........	25 17	82 40	1:3.27	41 82	40 58
1898.........	27 63	91 40	1:3.30	46 05	45 35
1899.........	38 54	115 00	1:2.98	64 23	50 77
1900.........	30 28	87 80	1:2.89	50 47	37 33
1901.........	27 95	81 50	1:2.91	46 58	34 92
Averages for 16 years....	$23 42	$90 39	1:3.96	$39 00	$51 33

It is interesting to note the exact relation between the prices of zinc ore and metallic zinc. Table VII has been prepared for this purpose. It gives such data covering a period of sixteen years, from 1886 to 1901, inclusive. Column 1 gives the year, then the price of sixty per cent. ore is given in the next column, then the price of spelter in New York, then the ratio between the two, then the price of a ton of metallic zinc while yet in the ore, and, lastly, the difference between the price of a ton of metallic zinc while still in the ore and after it is smelted and shipped to the New York market. This difference is the sum which must cover the following items: (*a*) Loss in handling and smelting; (*b*) all transportation charges, including loading of ore; (*c*) cost of smelting; (*d*) profit.

It will be noticed that the ratio, column 4, has gradually decreased since 1891, when it was the highest, and also that the

above-mentioned margin has likewise gone down. However, when the price of spelter is high the ratio may be low, and yet leave a fair margin, as was the case in 1899. During that year the smelters had a margin of $50.77 on every ton of spelter sold, while for 1901, with the ratio almost the same, they had a margin of but $34.92, which must mean that their profits were much less per ton. This corresponds with the well-known fact that smelters using coal for fuel have been compelled to shut down, as those using natural gas can produce spelters so much more cheaply.

A study of table VI and also table VII will show the relation between the price of ore and that of spelter. The changes in the price of ore in most cases lagged a little behind that of spelter, but not always. In general, there was a tolerably close relation between the two. This is greatly in contrast with the conditions which prevailed years ago, when there was little relation between the price of spelter and that of ore.

An examination of table VI also shows fluctuations in prices of lead ore. For years there has been a tolerably close relation between the lead-ore market and pig lead. Any cause, therefore, which worked a depression on pig lead immediately had a like influence on lead ore.

Zinc Smelting.

During the years 1900 and 1901 the zinc smelters of Kansas yielded the largest annual production of any period in the history of the state. It aggregated 57,856 tons in 1900 and 81,542.3 in 1901. The average price of spelter in New York was $87.80 per ton for 1900, and $81.50 for 1901, which gives the Kansas production a value of $5,081,512.80 for 1900 and $6,645,697.45 for 1901. The increase in tonnage of spelter is over 7000 tons for 1900 and over 33,000 tons for 1901. The price being greatly reduced since 1899, the total value of the same for 1900 falls about a million dollars below that of 1899, but is passed in 1901. Table VIII exhibits the production, price and value of spelter produced in the state from 1882 to 1901, inclusive. Recently zinc smelting has been confined almost

entirely to the gas-fields of the state; that is, to the vicinity of Iola and La Harpe, principally, with the large Edgar furnaces at Cherryvale. The increased production of spelter is due to economy of the gas furnaces. This has caused a much greater proportion of ore from the Joplin district to come to Kansas territory for smelting. The total production of spelter in America for 1900 is a little under 123,000 tons (see table IX), of which Kansas produced nearly forty-seven per cent., making an increase in ratio over 1899 of about five per cent. In 1901 the increase was still greater. In this year America produced 123,381 tons, of which Kansas smelted 81,542.3 tons, or over sixty-five per cent., making a net gain over the ratio of the preceding year of eighteen per cent.

TABLE VIII.

SHOWING AMOUNT AND VALUE OF METALLIC ZINC PRODUCED AT KANSAS SMELTERS, 1882 to 1901, INCLUSIVE.

Price per ton in New York.
(Data 1882 to 1896 from United States Geological Survey statistics.)

YEAR.	Amount in short tons (2000 pounds).	Price per ton in New York.	Total value.
1882..........	7,366	$110 60	$814,679 60
1883..........	9,010	90 60	816,306 00
1884..........	7,859	89 60	704,466 40
1885..........	8,502	86 80	737,973 60
1886..........	8,932	87 90	785,122 80
1887..........	11,955	92 80	1,109,424 00
1888..........	10,432	98 34	1,025,902 88
1889..........	13,658	100 20	1,368,531 60
1890..........	15,199	108 75	1,652,891 25
1891..........	22,747	108 82	2,475,336 96
1892..........	24,715	89 78	2,218,912 70
1893..........	22,815	80 37½	1,733,755 63
1894..........	25,588	70 43	1,902,162 84
1895..........	25,775	71 04	1,831,056 00
1896..........	20,759	79 70	1,653,592 30
1897..........	33,443	82 40	2,755,703 20
1898..........	38,543	91 40	3,508,524 27
1899..........	52,664	115 00	6,056,360 00
1900..........	57,876	87 80	5,028,832 80
1901..........	81,542.3	81 50	6,645,697 45
Total......	499,380.3	$91 19	$44,824,932 23
Estimation of zinc smelted previous to 1882..................................			2,575,000 00
Grand total..........................			$47,400.232 28

The Gas Furnace. Furnaces for smelting zinc ores by the use of natural gas do not differ in any essential respect from those using coal, excepting in the mechanical application of the fuel. The calcining furnace is essentially a reverberatory furnace. It may consist of a long, slender chamber with one floor, or a higher chamber with two or more floors. The ore may be stirred by hand or by machinery. Gas is admitted through proper openings in the walls and is mixed with air before entering the furnace. In most cases gas enters at a number of places, so that the heat may be properly regulated in all parts of the furnace. The common method of mixing gas with air is about the same as that embodied in the ordinary Bunsen gas lamp of our laboratories; that is, fitted over the end of a gas-pipe is a large thimble, so constructed that the outflow of gas through a small opening in the pipe draws with it through the thimble a proper amount of air. These mixers vary slightly in construction at different furnaces, but are essentially the same, in that air is drawn in by means of the rushing current of gas. The two are thoroughly mixed before ignition takes place. For the roasting furnace an excessive amount of air is necessary, which amount may be gathered from the mixers, or may be admitted at separate places, the former method being the one generally employed.

The retort furnace is built after the same fashion as those using coal for fuel, excepting that the furnace may be much longer on account of the ease with which fuel, properly mixed with air, may be added from any place along the sides. The retorts employed are circular in cross-section, with an internal diameter of about ten inches, a thickness of wall of an inch and a fourth, and a length of four and a half to five feet. The height of the retort furnace, that is, the number of rows of retorts, is about the same as that of the coal furnace, experience showing that it is not desirable to increase the height to any considerable extent. The fuel consumed is entirely outside the retorts, so that the heat is conveyed through the walls of the retort to the coal and ore within.

The process of zinc smelting is about as follows: First, if

necessary, the ore is dried by being heated on a brick or clay floor. Next, if coarse, it is crushed to moderate fineness, and then placed in the calcining or roasting furnace. It is admitted to this furnace at the coldest end, so that its temperature is gradually increased as it is worked downward to the exit end of the furnace. During this process of gradual transmission it comes continually into the hotter parts of the furnace, throughout all of which there is an excessive amount of free air, so that the sulphur of the ore is oxidized and driven off in the form of sulphur dioxide, SO_2, leaving the zinc behind in the form of zinc oxide. The length of time required to complete the oxidation of a given charge of ore varies considerably in different furnaces, or in the same furnace at different times. Some operators will work it through from one end of the furnace to the other in twelve hours, or less, while others keep the same ore in the furnace considerably longer.

As soon as the sulphur is all driven off the ore is ready to be removed. As the furnaces are constructed, roasting is almost a continuous process; that is, ore is added to the cool end of the furnace at frequent intervals, and comes out from the hot end likewise at frequent intervals, leaving the greater part of the furnace covered all the time with ore.

From the calcining furnace the ore is taken to the retort furnace, having been crushed again if necessary. Before being charged into the retorts the zinc oxide is thoroughly mixed with a proper amount of a reducing agent, which is principally crushed coke, and bituminous coal. Recently a number of smelters have been experimenting with the use of crushed anthracite coal to take the place of coke. In general, it seems that this is not very satisfactory, although some of the operators report that it does very well. Others stated that, when the residual part of the charge is drawn from the retort, they notice the shining particles of anthracite almost unchanged, indicating that it did almost no good in the charge. The bituminous coal is added to the charge in order that the illuminating gas driven off early in the process of reduction may start an outflow of gas from the retort.

Brick Plant of Coffeyville Vitrified Brick Company, Cherryvale.

The charge is shoveled into the retorts as they rest in place in the furnace. The outer end of the retort is then closed with a fire-clay cone, the large end of which fits snugly into the open end of the retort, the opening of the small end being about two and a half to three inches in diameter. This outer opening is entirely closed with soft fire-clay, excepting a small opening at the top which permits the gaseous products to escape. As the charge in the retort becomes heated, chemical action takes place between the carbon of the coke and zinc oxide, whereby the carbon is oxidized, leaving zinc in the metallic state. The heat is sufficiently great to volatilize the zinc, driving it over into the fire-clay cone, which is outside the furnace. The temperature there is sufficiently low to permit zinc vapor to change back to molten zinc. It is now drawn at intervals from the cones into ladles and molded into pigs of spelter.

Our Kansas smelters make no attempt to refine the spelter produced, nor to manufacture it into any kind of ware, but sell it on the market as furnace spelter.

The World's Production of Metallic Zinc.

During the year 1900 there was a decided falling off in the world's production of metallic zinc. Table IX shows the total foreign production by countries, and also the American production, from 1884 to 1901, inclusive. It is an interesting table, showing, as it does, that from 1884 to 1899, with but few unimportant exceptions, there was a regular and rapid increase in the production of metallic zinc. The total foreign production in 1899 was over 372,000 tons, with a domestic production of over 123,000 tons, or a domestic production of nearly 27 per cent. For 1900 the foreign production fell below 290,000 tons, while the American production was almost constant, being 122,885 tons. This makes the American production 29.86 per cent. of the world's production—a very handsome increase over the corresponding per cent. for 1899.

TABLE IX.

SHOWING WORLD'S PRODUCTION OF METALLIC ZINC FROM 1884 TO 1901, INCLUSIVE.

From Nineteenth Annual Report Director United States Geological Survey, part VI, pp. 223 and 224; foreign figures reported by Henry M. Merton & Co., London, England. Figures since 1898 from *Engineering and Mining Journal.*

Year.	Rhine district and Belgium.	Silesia.	Great Britain.	France and Spain.	Austria.	Poland.	Total foreign.	America.	Grand total.	Per cent. American.
1884	127,240	76,116	29,259	15,341	6,170	4,164	260,290	34,414	294,704	8.56
1885	129,754	79,623	24,299	14,847	5,610	5,019	259,152	36,329	292,659	8.05
1886	129,020	81,630	21,230	15,305	5,000	4,145	256,330	38,072	294,402	12.93
1887	130,995	81,375	19,839	16,028	5,388	3,580	257,155	44,946	302,101	14.87
1888	133,245	83,375	26,783	16,140	4,977	3,785	268,305	49,913	318,218	15.68
1889	134,648	85,665	30,806	16,785	6,330	3,026	277,248	52,553	329,801	16.23
1890	137,630	87,475	29,145	18,240	7,135	3,620	283,245	57,860	341,105	16.96
1891	139,695	87,080	29,410	18,360	6,440	3,760	284,745	72,208	356,953	20.22
1892	143,305	87,760	30,310	18,662	5,020	4,270	289,327	77,910	367,237	21.21
1893	149,750	90,310	28,375	20,585	7,560	4,530	301,110	70,385	371,495	18.93
1894	152,420	91,145	32,065	21,245	8,580	5,015	310,470	67,257	377,727	17.80
1895	172,135	93,620	29,495	22,895	8,355	4,960	331,460	80,077	411,537	19.45
1896	179,730	95,875	25,880	28,450	9,255	6,165	345,355	72,767	418,122	17.43
1897	184,455	94,045	23,430	32,120	8,185	5,760	347,995	89,268	437,263	20.41
1898	191,836	99,233	27,635	32,649	7,229	5,664	364,246	103,515	467,761	22.10
1899	192,994	100,160	32,223	33,482	7,305	6,325	372,496	123,194	495,690	26.87
1900	189,994	102,316	30,307	44,200	6,836	5,969	288,525	122,885	411,375	29.86
1901	....	....	....	....	......	......	....	155,206	....	....

The Spelter Market.

The spelter market for 1900 was far below that for 1899, having an average for the year of $4.39 per 100 pounds, against $5.75 for the previous year. Compared monthly, we find that the decline was very steady. In January, it was $4.65; in February, $4.64; March, $4.60; April, $4.71; May, $4.53; June, $4.29; July, $4.28; August, $4.17; September, $4.11; October, $4.15; November, $4.29; December, $4.25. Table X shows the average price by months and the yearly price for spelter from 1893 to 1901, inclusive. It will be noted that the average price for 1900 is a little above the average for the nine years, while the price for 1901 is below the same average. An examination of the same table fails to reveal any particular relation between the price of spelter and the time of year. Thus, in 1899 the highest monthly price was for May, $6.88; while the average for the year was more than $1 below, being $5.75. In the same month in 1894 the price was $3.37, the lowest of any month in the year, excepting November, which was $3.36. Yet, for the entire nine years, the lowest average monthly price is for January, $4.11, while the lowest monthly price in 1900 was September, being the same figures, $4.11. It would seem, therefore, that there is no definite relation between the market and the time of year.

Uses of Spelter.

In our report for 1899, page 34, is a discussion of the uses of spelter, which sums up the whole matter as follows, being a quotation from a letter received from Mr. R. P. Rothwell: "I am informed that it is principally used in galvanizing, for brass and yellow metals, for electrical purposes, sheet metal, and in the cyanide processes. The consumption is about as follows: Twenty per cent. sheet, fifteen per cent. brass and yellow, fifty per cent. galvanized, and fifteen per cent. sundries. Of course these figures vary according to the conditions of the trade."

The uses of spelter throughout the world during the past year have varied so little from those of the year preceding that

no marked variation could be noted. With seventy per cent. or more of the consumption being devoted to the production of galvanized ware and sheet zinc, it is evident that the demand for spelter will depend principally upon these uses for some time to come. In America our great demand is in the manufacture of galvanized wire for fencing, and of galvanized iron for construction purposes, with the sheet zinc being the next prominent use. It is probable that the total consumption of zinc in cyaniding works of the world hardly affects the markets to any considerable extent.

TABLE X.

SHOWING AVERAGE MONTHLY AND YEARLY PRICE OF METALLIC ZINC—"SPELTER"—IN NEW YORK FROM 1893 TO 1901, INCLUSIVE.

(Partly from *Engineering and Mining Journal*, January 5, 1901, page 24.)

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	cts.	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*	*cts.*
1893............	4.39	4.39	4.28	4.38	4.41	4.27	4.13	3.89	3.69	3.68	3.65	3.80	**4.08**
1894............	3.56	3.85	3.89	3.62	3.37	3.40	3.43	3.38	3.44	3.45	3.36	3.43	**3.52**
1895............	3.28	3.20	3.23	3.30	3.50	3.65	3.75	4.15	4.30	4.10	3.55	3.49	**3.63**
1896............	3.75	4.03	4.20	4.09	3.98	4.10	3.97	3.76	3.60	3.72	3.99	4.14	**3.94**
1897............	3.91	4.02	4.12	4.13	4.21	4.21	4.32	4.26	4.18	4.17	4.03	3.89	**4.12**
1898............	3.96	4.04	4.25	4.26	4.27	4.77	4.66	4.58	4.67	4.98	5.29	5.10	**4.57**
1899............	5.34	6.28	6.31	6.67	6.88	5.98	5.82	5.65	5.50	5.32	4.64	4.66	**5.75**
1900............	4.65	4.64	4.60	4.71	4.53	4.29	4.28	4.17	4.11	4.15	4.29	4.25	**4.39**
1901............	4.13	4.01	3.91	3.98	4.04	3.99	3.95	3.99	4.08	4.23	4.29	4.29	**4.07½**
Av. for 9 yrs.,	**4.11**	**4.27**	**4.31**	**4.35**	**4.35**	**4.30**	**4.26**	**4.20**	**4.17**	**4.20**	**4.12**	**4.12**	**4.23**

III.—COAL.

THE total output of coal from the Kansas mines for the year 1900 was the greatest in the history of the state, both regarding tonnage and aggregate values. The Hon. Edward Keegan, State Secretary of Mining Industries, kindly furnished advance sheets of his estimate, which is the source of information in the included tables for 1900. The total tonnage production is 4,269,716. Table XI shows the annual production since 1880, with price per ton. According to his figures, the average price of coal in the state at the mines for 1900 was $1.2883, which gives a total value of $5,500,709.58. Of the total tonnage, Crawford county produced 2,335,998 tons and Cherokee county 1,357,631 tons, a total of 3,693,629 tons for the Crawford-Cherokee field, or a little more than 86.5 per cent. of the entire production. Leavenworth county is third in production, with a credit of 250,183 tons, or 5.857 per cent. Osage county is fourth, with a credit of 194,618 tons, or 4.536 per cent. These four counties, therefore, aggregate 96.9 per cent. of the total production. A total of seventeen counties are producers of coal, but the remaining thirteen, of course, produce small amounts.

In 1901 the output increased slightly, reaching 4,793,374 tons, which, at $1.30 per ton, had a value of $6,231,386.

Geologically considered, the Cherokee shales are by far the strongest producers, as shown in table XII. The importance of this shale bed as a coal-producer is shown at the right hand of the table, where the per cent. of coal production for the different geological horizons is given. It will be seen that during the last four years the Cherokee shales have produced an increasing proportion of the total state production, there being but slight oscillations in the per cent. from year to year. With more than ninety-three per cent. of the total coal production

TABLE XI.

SHOWING COAL PRODUCTION IN SHORT TONS (2000 LBS.), 1880 TO 1901, INCLUSIVE.

With price per ton and value of yearly product.

YEAR.	Production in short tons (2000 pounds).	Price per ton.	Value of yearly product.
1880*	550,000	$1 30	$715,000
1881*	750,000	1 35	1,012,300
1882*	750,000	1 30	975,000
1883*	900,000	1 28	1,152,000
1884*	1,100,000	1 25	1,375,000
1885	1,440,057	1 23	1,770,270
1886	1,350,000	1 20	1,620,000
1887	1,570,079	1 40	2,198,110
1888	1,700,000	1 50	2,550,000
1889	2,112,166	1 48	3,126,005
1890	2,516,054	1 30	3,170,870
1891	2,753,722	1 31	3,607,375
1892*	3,007,276	1 31½	3,954,568
1893	2,881,931	1 37½	3,960,331
1894	3,611,214	1 35⅝	4,899,774
1895	3,190,843	1 12½	3,590,141
1896	3,191,748	1 01⅛	3,227,357
1897	3,291,806	1 07	3,488,380
1898	3,860,405	1 08½	4,193,159
1899	4,096,895	1 25	5,124,248
1900	4,269,716	1 28	5,500,709
1901	4,793,374	1 30	6,231,386
Totals	52,697,286	....	$67,441,984
Output previous to 1880	3,000,000	1 50	4,500,000
Grand totals	55,697,286	....	$71,941,984

*Figures for 1880 to 1884, inclusive, and 1892, taken from United States Geological Survey reports. All others taken from reports of State Inspector of Coal Mines.

coming from these shales, it is apparent that other coal-fields are of little importance as producers under present conditions.

The Cherokee shales lie at the base of the Coal Measures. The Osage shales lie about 1750 feet above them. They produce nearly five and five-tenths per cent. of the total production, leaving but little over one per cent. to be obtained from the 1750 feet of Coal Measure formations lying between these two great shale beds. The small amount of coal obtained from the Cretaceous beds to the west is important to parties operating the mines, but, compared with other parts of the state, it is very insignificant. It is hoped the new developments in Jewell county may appreciably increase the western production.

New Developments.

Few new developments in the way of discovering new coal territory were made during the past two years. A prospect well was drilled at Atchison, which resulted in the discovery of a three-foot bed of coal at a depth of 1126 feet beneath the surface. The well is situated on the west bank of the Missouri river, about two and one-half miles below the union depot. It was drilled by the Sullivan Machine Company, of Chicago, at the instance of public-spirited citizens of Atchison, who contributed liberally to the project.

The University Geological Survey had previously expressed an opinion that there was a strong possibility of coal being found. This statement was rendered from the well-known fact that the Cherokee shales passed to the northwest, and must therefore underlie Atchison. They were reached at a depth of about 828 feet and continued to a depth of 1305 feet, making them nearly 500 feet thick at that place. Coal was found in eighteen different places; three of which may possibly be of economic importance. At a depth of 800 feet, twenty-two inches of coal was found, which seems to correspond with the Leavenworth coal; at a depth of 1126 feet, thirty-six inches of coal was found; and at a depth of 1190 feet, twenty-eight inches of coal was found. The remaining thin beds of coal aggregate forty-seven inches, making a total of over eleven feet of coal passed through by the well, all but eighteen inches of which was in the Cherokee shales. We have, therefore, at this place, within the Cherokee shales, nine and one-half feet of coal, besides a comparatively large quantity of rich bituminous shales.

By special arrangement made with the prospecting company, the Survey kept an assistant at the well during the entire time drilling was in progress. The core was delivered to him directly from the core barrel, was examined, boxed, carefully labeled, and shipped to the University museum, where it is now lodged. The first two heavy beds of coal, the one at 800 feet and the one at 1126 feet, were carefully sampled by the writer, and submitted to Mr. E. B. Hayes, who analyzed them.

See table XII.

...TIES						

	Per Cent. of State Output by						
...92.a	...0.	1891.	1892.	1893.	1894.	1895.	189...
.....							
...9,524	...09	81.53	81.97	85.653	88.796	85.99	74....
...13,423							
2,000							
...28,307							
	41	1.41	1.46	2.571	1.619	1.02	.4...
...55,645							
......	...	......	......	......	......	......	......
......							
......							
...20,671	...35	.37	.37	.768	.512	.77	.5...
......							
......							
......							
......							
6,80...	...59	12.93	12.55	10.589	8.587	8.70	5.9...
......							
......							
59,228							
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......	...	......	......	.419	.487	.34	......
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54,56...	...	......	......	......	......	......	......

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Analysis of Coal from Atchison Prospect Well. By E. B. Hayes, Analyst.

	Fixed carbon	Volatile and combustible	Ash	Moisture	Total sulphur	Fixed sulphur	Volatile sulphur	Iron oxide	Phosphorus	Color of ash.	Form of ash.
Thirty-six in. vein (av. sample)	46.69	41.70	7.13	4.48	2.62	.00	2.62	3.06	Trace	Grayish pink	Light, flaky.
Duplicate	46.81	42.13	7.11	3.95	2.57	.00	2.57	......	"	" "	" "
Thirty-six in. vein (best sample)	48.14	44.82	4.92	2.12	1.96	......	......	......	......	" "	" "
Duplicate	48.49	44.50	5.01	2.00	1.95	......	......	......	......	" "	" "
Average	47.53	43.29	6.04	3.13	2.27	......	1.71	......	......	" "	" "
Twenty-two inch vein	43.92	38.71	14.48	2.89	5.85	0.11	5.74	......	......	Reddish brown	Rather coarse, light, and clinker.
Duplicate	43.69	39.27	14.41	2.63	6.33	0.10	6.23	......	......	" "	"
Average	43.80	38.99	14.44	2.76	6.09	0.105	5.98	......	......	" "	"

The entire record, with elaborate notes by Mr. L. N. Morscher, one of the parties who watched the drilling, is so important a record of the strata of the Coal Measures at this place, as well as so full a description of the physical characteristics of the strata, that it may well be published entire, although it has already been published in part by Mr. A. E. Langworthy. Plate I is a drawing made to represent the same, and may be studied in connection with the log.

Log of Atchison Deep Well, with Notes on Same.

By L. N. Morscher.

Note.—The term "slickensides," as here used, is borrowed from the drill operators, and refers to seams or cracks of any kind which have smooth, shining walls. Probably none of them are like ordinary slickensides.

No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
1	Clay and loose rock	18—0	18—0
2	Clay shale	6—0	24—0
3	Sandstone, very shaly, of thin, uneven laminæ, alternating between light gray and very dark gray	7—0	31—0
4	Shale, light in color, with many sandstone streaks in it	33—0	64—0
5	Sandstone, very calcareous, being almost a limestone in places, with many small fossils	1—2	65—2
6	Shale, blue, with streaks of sandstone and limestone; a heavy lamina of sandstone occurring at 103; merges into next; some pyrite-covered fossils occur at 100-6 and 101	39—10	105—0
7	Limestone, nodular, with some shale and fossils	2—0	107—0
8	Shale, sandy	53—0	160—0
9	Sandstone, with many pyrite nodules, especially at 163	7—0	167—0
10	Shale, dark blue, rather sandy	9—0	176—0
11	Sandstone, of light color, fine grain, firm texture	3—0	179—0
12	Shale, sandy, very streaked, a soft place occurring from 183 to 183-6; the shale merges into sandstone	11—0	190—0
13	Sandstone, shaly, which by an uneven surface joins onto the limestone beneath	34—0	224—0
14	Limestone, hard, dark blue	2—0	226—0
15	Shale, blue, with much contorted, wavy layers; some nodular pyrite occurs in upper portion	8—0	234—0
16	Sandstone, shaly	2—0	236—0
17	Shale, sandy, merging into sandstone, with very uneven grains and lenticular layers	3—0	239—0
18	Sandstone, uneven-grained, and lenticular layers of light and dark colors; very soft at 243 and merges into limestone below	5—0	244—0

No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth ft. in.
19	Limestone, the first foot buff, somewhat brecciated, then two feet dense, smooth, and of blue color, then rock hardens, with many lighter and cherty patches; contains many small fossils; shale partings occur—about two inches at 251, four inches at 257, two inches at 258, and three inches at 261; stone very silicious at 263, and at 264 it merges into blue sandstone	20—0	264—0
20	Sandstone, blue, merging into sandy shale	3—10	267—10
21	Shale, sandy, parted by slickensides from the limestone beneath	0—2	268—0
22	Limestone, shading from light blue to buff, merging into shaly sandstone	1—0	269—0
23	Sandstone, shaly, with lenticular-shaped layers; a five-inch layer of breccia and slickensides occurring at 271	12—0	281—0
24	Shale, blue	2—0	283—0
25	Limestone, the first four feet porous, of oolitic tendency, and rather dark; lower stratum lighter in color and dense in structure, rapidly merging into the shale below,	8—0	291—0
26	Shale, sandy, with sandstone masses at 326; merges through coarse sand into the limestone below	35—0	326—0
27	Limestone, in alternate layers, of light color and smooth grain, from two to three inches thick, and dark, sandy limestone layers, from one-half inch to twelve inches thick; layers firmly joined together by very uneven surfaces	11—0	337—0
28	Shale, blue, carrying many fossils and much pyrite, well defined from limestone below	3—0	340—0
29	Limestone, hard, blue, with upper surface covered with coal flecks; bed contains many streaks of lighter-colored limestone and patches of darker flint, some of which are five inches across; upper portion of bed has many vertical seams filled with white flint; also sandy patches one to three feet apart; crystalline from 343 to 345, somewhat oolitic, and contains many small fossils; 345 to 346 contains many large fossils; a three-inch shale parting at 345 and a six-inch dark blue shale parting at 348; sandy limestone below	9—0	349—0
30	Shale, blue, very dark at 350	2—8	351—8
31	Shale, black, one inch very dark and tarry, giving flame when ignited	1—4	353—0
32	Sandstone; dark masses of limestone nodules and coarse sand well cemented	1—0	354—0
33	Shale, blue, mortar-like, with coarse sand and grains of pyrite; slickensides at 356, 357-2, 360, 361, 361-6	9—0	363—0
34	Limestone, very porous at 363 and 364, middle portion dense, hard, and of blue color, last two feet streaked with dark lenticular masses, finally merging into shale,	5—0	368—0
35	Shale, green, with limestone nodules at 369-6 to 371; slickensides at 373	5—0	373—0
36	Shale, blue, slickensides at 373, and last five inches full of limestone nodules; merges into limestone	5—0	378—0
37	Limestone, very light in color at 379, soon becomes nodular, and at 383 changes into shale mixed with limestone	5—0	383—0

No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
38	Shale, mixed with limestone, with a four-inch shale parting at 384–9 and a twelve-inch parting at 385	4—0	387—0
39	Limestone, very white, the upper surface rough and uneven,	1—0	388—0
40	Shale, blue, mixed with limestone bands	4—0	392—0
41	Limestone, dark-banded, contains many fossils	5—0	397—0
42	Shale, black	2—0	399—0
43	Shale, dark blue, containing many fossils	9—0	408—0
44	Limestone, containing much shale and many fossils; merges through fossiliferous shale containing limestone nodules into a dark shale	3—0	411—0
45	Shale, dark blue	1—0	412—0
46	Limestone; a concretionary mixture of fossil-bearing limestone and shale	5—6	417—6
47	Limestone	0—6	418—0
48	Limestone, very nodular and shaly	1—0	419—0
49	Shale, smooth, blue, with fossils	4—0	423—0
50	Shale, blue, which darkens and becomes filled with limestone nodules toward the bottom	4—0	427—0
51	Limestone, very nodular, with shale	2—6	429—6
52	Limestone, nodular	5—6	435—0
53	Limestone nodules, with shale	4—0	439—0
54	Limestone, fossil bearing, with dark streaks, containing many fossils; a shale parting at 443	9—0	448—0
55	Limestone, with last two inches nodular	6—0	454—0
56	Shale, blue, with some limestone	8—0	462—0
57	Limestone nodules, cemented with shaly material	2—0	464—0
58	Limestone, blue and fine-grained, with pyrite crystals and many horizontal seams of partings	9—0	473—0
59	Limestone, blue and fine-grained, with dark horizontal streaks every twelve or eighteen inches	8—0	481—0
60	Shale, dark blue, merging into black shale, the blue containing many fossils and the black much pyrite	4—0	485—0
61	Limestone	0—6	485—6
62	Shale, black	0—6	486—0
63	Limestone	0—6	486—6
64	Limestone, dense, two inches fossiliferous at 497	15—0	501—6
65	Shale, blue, resting on a parting of bituminous coal too thin to measure	1—0	502—6
66	Shale, sandy	0—7	503—1
67	COAL parting, one-eighth inch.		
68	Shale, sandy	0—5	503—6
69	COAL parting, one-eighth inch.		
70	Shale, sandy, even-grained	4—6	508—0
71	Shale, sandy, the last two feet close-grained, with light-grained sandstone bands	4—6	512—6
72	Shale, dark and sandy	0—6	513—0
73	COAL	0—1	513—1
74	Shale, coarse, sandy, with limestone nodules	1—11	515—0

No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
75	Shale, sandy, with pyrite at 516	4—0	519-0
76	Limestone, light-colored	1—0	520—0
77	Shale, dark and sandy, with uneven, light-colored layers, streaked with sandstone; many fossils	42—0	562—0
78	Clay shale, rather firm	15—0	577—0
79	Shale, blue, close-grained	5—0	582—0
80	Shale, blue, very wavy-layered	2—0	584—0
81	Sandstone, fine-grained, shaly, with many lenticular masses of pure sandstone and wedges of limestone; a limestone parting of one inch occurs at 585–5, while the last six inches are very calcareous	5—0	589—0
82	Shale, blue clay, very friable	6—0	595—0
83	Shale, clay, fine-grained, of varying colors, blue, yellow, red, etc., and very calcareous, especially at 596	2—0	597—0
84	Shale, clay, very friable	1—0	598—0
85	Shale, clay, of red and yellow marbling	1—0	599—0
86	Shale, calcareous, the grain being very curly at 601 to 603, resembling graining of wood about a knot; many limestone nodules occur at 602 and slickensides at 603 and 605	7—0	606—0
87	Shale, red, clay, full of slickensides between 607 and 612, the angle of slickenside parting about thirty degrees from the horizontal	6—0	612—0
88	Shale, smooth, dark blue	2—0	614—0
89	Limestone, fairly dense and granular, the upper surface uneven and shaly	0—6	614—6
90	Shale, red	1—6	616—0
91	Shale, blue, clay, which merges into sandstone	2—0	618—0
92	Sandstone, gray	4—0	622—0
93	Shale, fine-grained, blue and sandy, with pyrite at bottom of layer	2—0	624—0
94	Shale, clay, firm and dark blue, the last twelve inches very dark, with slickensides at 625–3, 625–4, 626, crossing at angle of forty to the horizontal, and at 268 at eighty degrees	3—6	627—6
95	COAL, which merges into black shale	0—3	627—9
96	Shale, black	0—2	627—11
97	Shale, dark and very calcareous, with many limestone bands; fossil plants in black shale	1—1	629—0
98	Shale, soft and friable, resembling fire-clay	2—0	631—0
99	Limestone	4—0	635—0
100	Shale, with limestone bands, color growing darker with depth	3—0	638—0
101	Limestone masses, very fossiliferous, with much shale, three-inch streak at 640–1; one inch at 640–5; one inch at 640–9; one inch at 641–1, and two inches at 642–7	5—6	643—6
102	Shale, dark blue, full of limestone streaks	6—0	649—6
103	Limestone, argillaceous, and clay shale, streaked and very curly grained	1—6	651—0

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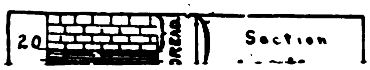
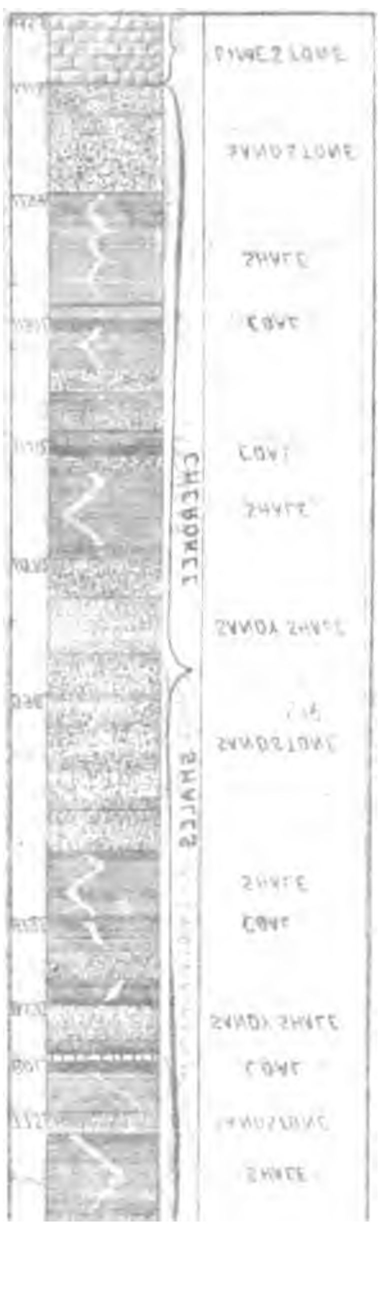
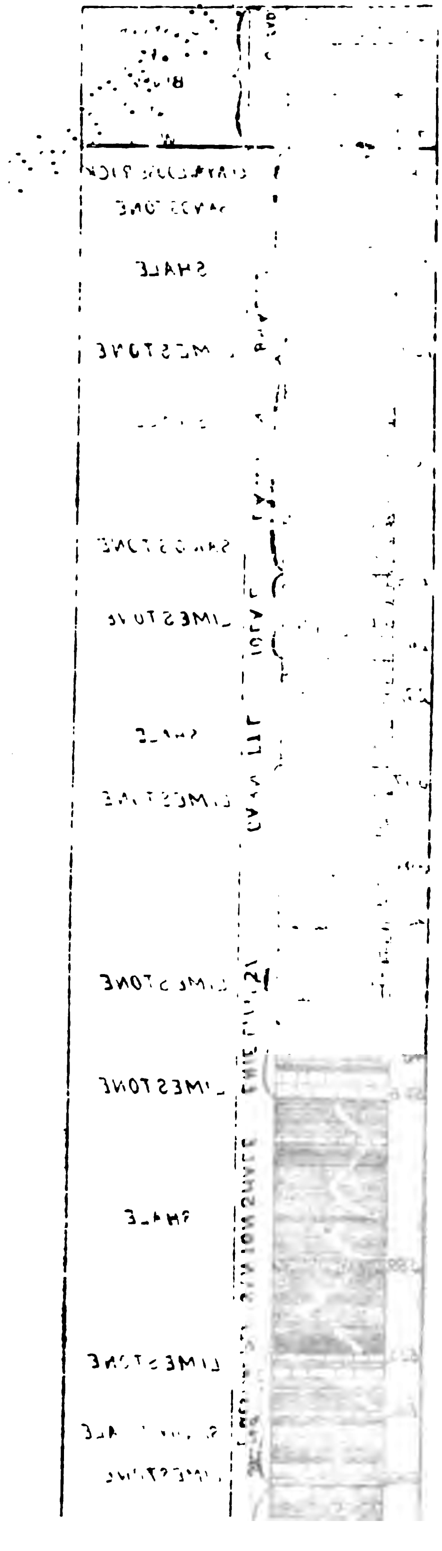
No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
140	Shale, sandy, slickensides at 45 and 30 degrees to horizontal, forming a wedge at 778–6; a coal-lined slickenside parting at 35 degrees to horizontal at 779–2, between sandy shale sides; coal streaks occur at 778–9; coal partings at 780–5, 780–10, 781–3, 781–4, 781–7, 781–9, 781–11, 782–2, 782–11, the last quarter inch being good coal; also a streak of fine-grained black shale with some sandstone at 785 to 786	14—9	793—0
141	Shale, dark, with many thin, fine-grained calcareous bands; shale firm and close-grained and slaty; last twelve inches almost clear of calcareous bands, few of which exceed one-half inch thick	6—0	799—0
142	**COAL**, appears to be a very good quality, but with some thin sand or shale streaks in it; the core roof does not show a sharp parting from coal, although coal is sharply defined from clay below by horizontal slickenslide	1—10	800—10
	Analysis of lower sixteen inches of coal, by E. B. Hayes: Moisture, 2.76; volatile combustible, 38.99; fixed carbon, 43.80; total ash, 14.44; sulphur, 6.24. The upper six inches of this coal is quite shaly, so it was not included in the analysis.		
143	Shale, very dark	0—1	800—11
144	Shale, blue, very friable, nodular, falling into lumps easily,	2—10	803—9
145	Limestone, mixed with shale gradually merging into limestone, with shale partings occurring at 804–2, 805, 805–6, 807	4—1	807—10
146	Shale, blue, very friable and nodular	2—8	810—6
147	Sandstone, calcareous, with shaly tendency	4—0	814—6
148	Shale, sandy	4—11	819—5
149	Shale, soft and sandy, as shown by drill and reamer cuttings	4—0	823—5
150	Shale, dark blue	0—5	823—10
151	Shale, very dark calcareous and sandy, so full of streaks and nodules of limestone as to be almost shaly, curly grained limestone; dark partings occur at 826–6 and 827–11, 828–1, dark, shaly from 828–1 to 829–4, the last merging into dark blue clay shale, a very dark parting at 829–4	5—6	829—4
152	Shale, light, firm and sandy, merging into sandstone	0—9	830—1
153	Shale, fine-grained, firm, dark, sandy	2—2	832—3
154	Shale, dark	1—1	833—4
155	Shale, firm and dark	1—2	834—6
156	**COAL**, rather brittle	1—0	835—6
157	Shale, dark, sandy, with black iron nodules and pyrite; also limestone nodules; pyrite especially plentiful at 837,	3—0	838—6
158	Shale, very dark, curly grained, and limestone nodules	0—6	839—0
159	Shale, dark	4—0	843—0
160	Shale, light calcareous and sandy, rough-grained, merging into next below	1—0	844—0
161	Shale, light and smooth-grained, merging into next below,	0—3	847—0
162	Sandstone, firm, light in color, with limestone concretions at 857–5 to 857–8	15—0	862—0

No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
163	Shale, dark, smooth	16—2	878—2
164	Pyrite, cemented with dark shale	0—3	878—5
165	**COAL**, fair quality, lower side showing fracture through which water came up and at or near which the salty water came in	0—9	879—2
166	Shale, light, sandy, of rather firm, massive texture, almost a fire-clay	2—10	882—0
167	Shale, soft, with dark, hard limestone, nodular, and an angular broken lump of coal being embedded in the core at 886, evidently broken from the vein above	4—0	886—0
168	Shale, light, sandy; the core had to be bored out, as it choked in core barrel of drill	1—0	887—0
169	Shale, coarse and sandy, with vertical veins of calcareous material	2—0	889—0
170	Shale, fine, sandy, with limestone nodules	1—0	890—0
171	Shale, sandy, with uneven vertical limestone seams; shale light in color	2—6	892—6
172	Shale, light	1—0	893—6
173	Shale, firm, sandy	6—0	899—6
174	Shale, hard, close-grained, sandy, the layers in some cases dipped 20 degrees to horizontal, mostly light blue-gray,	10—2	909—8
175	Shale, very sandy, layers tipped 40 degrees to horizontal	2—4	912—0
176	Sandstone, shaly, micaceous, layers tipped 30 degrees	1—5	913—5
177	Shale, very sandy, almost a sandstone, with sandstone partings	1—0	914—5
178	Sandstone, many dark layers, dipped 20 degrees; shaly 928 to 930, and rather clear, fine grained at 914 to 924	21—7	936—0
179	Sandstone, full of carbonaceous streaks, 936 to 937-2; 937-2 to 937-9, clear-grained sandstone; 937-9 to 938-6, sandstone much filled with coal; 938 to 940-2, gray sandstone almost free from coal; at 940-2 a quarter-inch coal parting between sandstone layers inclined at 15 degrees; 940 to 940-2, uneven coal streaks and sandy nodules embedded in sandstone; 940-6 to 942, clay with thin streaks or markings of coal; 942 to 942-5, sandstone with coal markings; 942-5 to 943-3, sandstone with many nodules and large irregular lumps of shale intermixed with coal; 943-3 to 943-10, sandstone with many coal specks; 1 inch of very sandy coal occurs at 943-8 to 943-9, being perhaps one-third coal; 943-9 to 945-10, sandstone with many coal partings, especially at 944, 944-2, 944-6, 944-8, 945, and 945-3, all of these being very sandy and of lenticular shape, rather embedded carbon masses than partings; shale nodules occur at 944-4, 945-2, and the mass is almost shale from 945-3 to 945-10; pyrite nodules occur at 943-10 and 944-8; 945-10 to 946-8, close, dark, very curly grained sandstone, the layers in some cases being inclined as much as 45 degrees to others; 946-8 to 947, sandstone with many markings, especially at 946-10, 946-11, 947; this portion also contains some pyrite; 947 to 948, sandstone mottled with light and dark muddy patches, the dark portions in some cases seemingly spheroids composed of concentric layers; 948-7 to 949-		



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No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
	6 is a very dark mixture of sandstone and coal; 949–6 to 952, light sand with some streaks of coal, especially at 949–9, 949–11, 950, 952, 952–1; 952 to 956–4 is gray sandstone, with dark patches at 953–9, 653–10, 954–8, 955 to 955–4; 955–4 to 955–8, many coal markings; 955–8 to 956–6, the sandstone shows an irregular graining almost like that of curly grained maple; 956–9 to 975, sandstone with some coal specks and muddy patches or markings, especially at 977 and from 981–6 to 985; at 981–6 a very dark micaceous sandstone occurs, inclined 45 degrees to the horizontal; 985 to 990, sandstone with many muddy patches, also shale partings at 986, 987, 987–6, the partings at from 40 to 45 degrees to the horizontal; 990 to 990–2, dark, heavy-grained sandstone with coal streaks, especially at bottom; 990 to 990–2, unevenly grained sandstone with coal specks; at 992–2 coarse sand and small gravel; at 992–2 lie two coal seams, the upper, horizontal one intersects a thicker coal parting which lies at 45 degrees to the horizontal; 992–2 to 995–10 is light, clear-grained sandstone	59—10	995—10
180	COAL	—1	995—11
181	Limestone nodules embedded in sandstone and shale, the sandstone and limestone being very dark	—7	996—6
182	Sandstone	11—3	1007—9
183	Sandstone, with some coal streaks, especially at 1008–4, 1014, and 1016; coal at the bottom	10—0	1017—9
	At 1008 feet, after the drill-rods were taken from the casing, water rose from thirty inches below the top to the top of the three-inch casing in seventy-five seconds, equaling 170 cubic inches per minute flow.		
184	Shale, dark and sandy, almost sandstone	2—8	1020—5
185	Shale, dark, with lenticular masses of gray sandstone showing color markings	27—7	1048—0
186	Shale, dark, sandy, with lenticular masses	2—0	1050—0
187	Sandstone, light gray, with carbonaceous streaks, at 1059, at forty degrees to the horizontal; also at 1063 to 1063–4 a coal parting	20—0	1070—0
188	Shale, blue, clay, and sandy	1—0	1071—0
189	Shale, smooth, firm-grained, and sandy	2—8	1073—8
190	Shale, very dark and friable	0—4	1074—0
191	COAL	0—2½	1074—2½
192	Sandstone, very dark, filled with pyrite, the rock very dense, hard, and unevenly grained	1—9½	1076—0
193	Shale, dark, carbonaceous, with embedded lenticular masses of sandstone	5—6	1081—6
194	Shale, light-colored and sandy, with many thin sandstone layers	5—6	1086—0
195	Shale with sandstone partings, and sandstone with shale partings; very irregular dark shale and light gray sandstone alternating, the layers being at all angles, from horizontal to thirty degrees from horizontal, the shale more or less carbonaceous in places	25—6	1111—6

No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
196	Shale, dark, with lenticular and fantastic nodules and sand partings	1—6	1113—0
197	Shale, dark, carbonaceous, with sandstone partings	1—2	1114—2
198	Sandstone, light gray, with clay partings, very greasy or soapy to the touch, at 1114–4, 1114–6, 1114–9, 1114–11, and 1115–2	2—4	1116—6
199	Sandstone, light gray, in thin layers, from one-fourth to in inches thick, with dark shale partings	2—4	1118—10
200	Shale, very dark, carbonaceous, almost a coal	0—10	1119—8
201	COAL	0—1	1119—9
202	Sandstone, cemented with shaly limestone. At this point salt water seemed to increase, as it could be tasted in the pump water very perceptibly	3—3	1123—0
203	Sandstone, light-colored and fine-grained	0—6	1123—6
204	COAL	3—0	1126—6
	Averages for entire 36 inches, by E. B. Hayes: Moisture, 4.11; volatile combustible, 42.02; fixed carbon, 46.75; total sulphur, 2.57; total ash, 7.12; iron as Fe_2O_3, 3.06. *Best sample:* Moisture, 2.06; volatile combustible, 44.66; fixed carbon, 48.31; total ash, 4.96; sulphur, 1.96.		
205	Sandstone	3—6	1130—0
206	Shale, very dark, and rich carbonaceous, with much pyrite,	3—9	1133—9
207	COAL	0—6	1134—3
208	Sandstone, hard and dense, with pyrite parting at 1134–7,	1—0	1135—3
209	Sandstone, clear gray	2—0	1137—3
210	Sandstone, with carbonaceous masses and streaks becoming more towards the bottom; many carbonaceous streaks at six inches and a foot from the bottom	7—9	1145—0
211	Shale, dark or black	3—0	1148—0
212	Sandstone, flinty, porous	0—5	1148—5
213	Sandstone, unevenly bedded with dark spots and shaly partings	1—1	1149—6
214	Shale, black	0—6	1150—0
215	Shale, a little less dark than the former	2—0	1152—0
216	COAL, some of it ground away in drilling	0—4	1152—4
217	Shale, dark, carbonaceous	0—4	1152—8
218	Sandstone, dense, dark gray	0—8	1153—4
219	Sandstone, light gray, with dark gray streaks and a few streaks of coal	3—3	1156—7
220	Sandstone, clear white, with but few dark streaks in it	0—3	1157—10
221	Sandstone, full of carbonaceous streaks	1—2	1159—0
222	Sandstone, soft; 1159 to 1159–2, clear, with but little carbon; 1159–2 to 1160–9, firm sandstone, full of carbon streaks; 1160–9 to 1161, firm sandstone, with some coal and some pyrite in it; 1161 to 1162, firm sandstone full of carbon, much of it in honeycombed or cellular nodules, also some pyrite in much the same form; the last ten inches are rather free from carbon and pyrite	6—10	1165—10

No. of stratum.	Kind of stratum.	Depth of stratum. ft in.	Total depth. ft. in.
223	Shale; black; 1165–10 to 1165–11, fine-grained, black shale; 1165–11 to 1166, black, with layers of coarse sand cemented with shale filling; 1166 to 1166–1, fine, black shale; 1166–1 to 1166–2, shale containing two layers or coarse sand; 1166–2 to 1166–6, black, carbonaceous shale, with many layers of coarse-grained sand, well cemented,	0—8	1166—6
224	COAL	0—2	1166—8
225	Shale, carbonaceous and black	0—2	1166—10
226	Shale, dark, fossiliferous; 1167–6 to 1168–6, black, with much pyrite; 1168–6 to 1169–6, black shale, with much pyrite; 1169–6 to 1174, black, carbonaceous shale, with many slickensides, which have high, mirror-like polish, especially between 1170 and 1173; shale is lighter and has more sand at 1172 and 1172–6; from 1174 to 1174–6, dark, with many carbon specks and some limestone; 1174–6 to 1177, black shale, with most limestone, especially from 1174–6 to 1176; from 1177 to 1179, shale is black and carbonaceous; 1179 to 1181, very black shale, with much carbon and some fine sand; 1181–3 to 1181–4 is dense, hard, bright pyrite partings; 1181–4 to 1185–3, a smooth, black, carbonaceous shale, with pyrite-filled seams, both vertical and horizontal; also some pyrite nodules. At this place, after stopping the drill-rods, the water rose from 7½ inches below the top to the top of 3-inch casing in 12 seconds, equaling 265 cubic inches per minute. This agreed with the flow as checked by measuring at surface. 1185–3 to 1187–9, black shale....	20—11	1187—9
227	COAL, first ten or fifteen inches soft, as shown by action of drill and cuttings brought up; the latter rather spongy under the teeth, and had a rotten-wood taste...	2—4	1190—1
228	Shale, black, 1190–1 to 1192–6; some sand at 1192–5; 1192–6 to 1197, dark shale, very hard and dense, much sand, and some sandstone markings, especially at 1193 to 1194–6; many carbon specks below 1196; 1197 to 1197–6, black shale, with much carbon in lenticular masses at 1197–2, 1197–4, 1197–6	7—5	1197—6
229	COAL, very brittle	1—3	1198—9
230	Shale, dark; 1198–9 to 1198–11, black shale; 1198–11 to 1200, dark clay shale, some sandstone and pyrite; a limestone layer filled with fossils at 1199; 1200 to 1201, dark blue shale, with many slickenslides; 1201 to 1203, dark brown shale, with sand and grains of pyrite; 1203–1 to 1214, black shale, with some pyrite; 1206 to 1209, shale, smooth-grained; 1210–4 to 1216–3, dark shale, containing many carbon specks and coal partings at 1215–6, 1215–11, 1216–1, also many coal masses as wedges, some pyrite, both coal and pyrite occurring especially plentiful at 1216–1 and 1216–3; 1216–3 to 1218–6, the shale is dark blue; 1218–6 to 1221–6, dark gray, sandy shale, very dense and fine-grained; 1223–6 to 1223–7, very clear; 1223–7 to 1224–3, dense, dark gray, sandy shale; 1224–3 to 1226–7, blue sand shale, close in grain, firm in texture; 1226–7 to 1248, dark sand shale, some slickensides, especially at bottom; 1248 to 1256–6, dark shale, full of highly polished slickensides, six inches of sandstone shale occurring at 1250 to 1250–6	57—9	1256—6

No. of stratum.	Kind of stratum.	Depth of stratum. ft. in.	Total depth. ft. in.
231	COAL	0—11	1257—5
232	Sandstone, shaly; 1257-5 to 1258-6, dark gray sandstone merging into clay; 1258-6 to 1296, sandstone full of black shale partings, both sandstone and partings containing many pyrite concretions and grains	40—1	1297—6
233	Shale, dark, with lenticular masses of sandstone; a little gas came from the depth of about 1298-6, enough to make a blaze 8 or 10 inches high; it could be lighted only by allowing the machinery to stand a few minutes and then pumping water down into the well; gas lighted soon after starting of drill on night of October 1, 1900	1—5	1298—11
234	Sandstone, coarse, of a dark brown color, almost flinty conglomerate, containing a little limestone and also thin wedge of coal at the bottom	0—1	1299—0
235	Sandstone, clear, loosely bound, coarse-grained, almost white in color, full of nodules of lighter colored sandstone, which are better cemented; these lumps grow more abundant toward bottom, some black sandstone streaks occurring at 1307 to 1307-4, 1308-8, 1309-3; from 1310-8 to 1311-4 much black standstone, forming a hard rock; 1311-4 to 1313-2 is light-colored, loose-grained, and porous; 1312-2 to 1314, the sandstone becomes brown, merging into gray limestone	16—0	1315—0
	Upon striking sandstone at 1299 the water flow nearly ceased; the amount was measured, but it was a mere dripping; the water did not follow the rods so much on lifting them, although before this flow had been kept up, if not increased, in drawing the rods up, which took 75 minutes; the first flow, struck at 879 feet, had choked up before the casing had been lowered to a depth of 886; the flow at the depth of 879 was about 170 cubic inches per minute when the well was standing open; this increased but little until a depth of nearly 1107 was reached when it began to increase; the flow was measured at a depth of 1185, when it was found to be about 265 cubic inches per minute when well was standing free. At a depth of 1299 the porous sandstone was struck and the flow ceased.		
236	Limestone, crystalline; from 1315 to 1316-6 of very gritty texture; 1316-6 to 1353, flinty and rather crystalline, hard, dense, smooth, bluish-white limestone, with some thin shale partings at 1324, 1326, 1328	38—0	1353—0

A few facts clearly established by the Atchison well record may be mentioned. The thickness of 500 feet of the Cherokee shales at this place is interesting, as it shows that they continue to the north and northwest uninterruptedly to so great a distance. Their large carbon content also shows that they were marginal deposits—at least, that they were gathered under conditions favorable for the production and preservation of large quantities of vegetable matter. The detailed account of the sandstones within the Cherokee shales, given in Mr. Morscher's notes, corroborates the above conclusion. The frequent appear-

ance of ripple marks and wave marks, clearly shown in the core, are especially emphasized by him.

The position of the various limestones and shale beds passed through by the well are good evidence that each formation is continuous to the northwest from their more easterly outcroppings—the same as in the southeastern part of the state. The positions they occupy also give evidence that little or no faulting or dislocation has occurred in this part of the state. Otherwise the strata would not be in place, as now found.

The coarse conglomeritic layer found immediately above the Mississippian limestone implies an erosive time period between Mississippian and Coal Measure times. The same condition is evidenced in many other places in eastern Kansas where deep wells have passed through the Coal Measures. The distance below the surface at which the base of the Cherokee shales is reached, 1315 feet, is a little greater than was expected. In the estimate made to the Committee of Forty, in the autumn of 1899, it was stated that the base of the Coal Measures might be expected to be reached anywhere from 1200 to 1300 feet. The well, therefore, shows that the dip of the rock to the northwest is a little greater than was previously considered. The elevation of the mouth of the well at Atchison is about 795 feet above sea-level, which would place the bottom of the Cherokee shales 520 feet below sea-level. Deep borings at Kansas City have shown that the bottom of the Cherokee shales there are almost exactly at sea-level. The air-line distance from Kansas City to the well is about fifty miles. This would give a dip to the northwest for the surface of the Mississippian of about 10.5 feet to the mile.

A deep well recently drilled at Saxton, Mo., already mentioned, about six miles east and a little south of St. Joseph, Mo., gave slightly different results, as the Mississippian limestone was reached at a shallower depth. This, in connection with surface indications, seems to imply that Atchison lies in a synclinal trough having an axis trending northwest and southeast. The coal at Atchison being more abundant than has been found further to the north or south, in connection with the

above, naturally leads to the inquiry, whether or not Atchison is not situated over an ancient lagoon in which coal of unusual richness was deposited. If this were true, one might reasonably expect the same or similar coal to be found further to the northwest at a depth which may be determined for any point by taking into account the westward dipping of strata. This is a question of great importance, and one which will be considered further by the Survey. The deep prospect wells already drilled in the vicinity of Horton are too shallow to test the question of the presence of coal, as none of them were carried deep enough.

The knowledge gained from this well throws light upon a number of problems connected with local and general geology. Starting as it does from near the base of a well-known horizon, the Oread limestone, and continuing to the base of the Coal Measures, it gives positive data regarding thickness of strata which are much more satisfactory than estimates made by measurements upon the upturned edges of nearly horizontal strata. This may become of even more importance than is recognized at present, as nearly all horizons connected with either coal, gas or oil in Kansas are penetrated. It has supplied heretofore missing data regarding the Atchison syncline, the existence of which is indicated at the surface, but not to as great an extent as in the lower levels. The character of the rocks adjacent to the contact line between the Coal Measures and the Mississippian is well shown, while the porous properties of the lowermost sandstone at the base of the Coal Measures may become of great importance from the engineering standpoint in connection with operations of mines working the deep-seated coal.

The Oread limestones have been traced entirely across the state of Kansas, from the south line near Sedan to the Missouri river just above Leavenworth, and up the river to where they pass permanently under the river level, near St. Joseph. Throughout this distance of over 200 miles they vary slightly in level, giving gentle undulations to their tracings on a vertical north and south section. But nowhere is the irregularity

in levels of the Oread equal to variations in level of the base of the Coal Measures.

At Atchison the base of the Upper Oread is about 862 feet above tide, at Leavenworth about 975, at Lawrence about 1002, opposite Ottawa about 1041, at Burlington about 1083. It therefore dips to the northeast about one and one-half feet to the mile from Burlington to Lawrence. From Lawrence to Leavenworth it retains about the same angle, dipping about one foot to the mile. But from Leavenworth to Atchison it dips 5.5 feet to the mile, or 3.5 feet to the mile from Lawrence to Atchison.

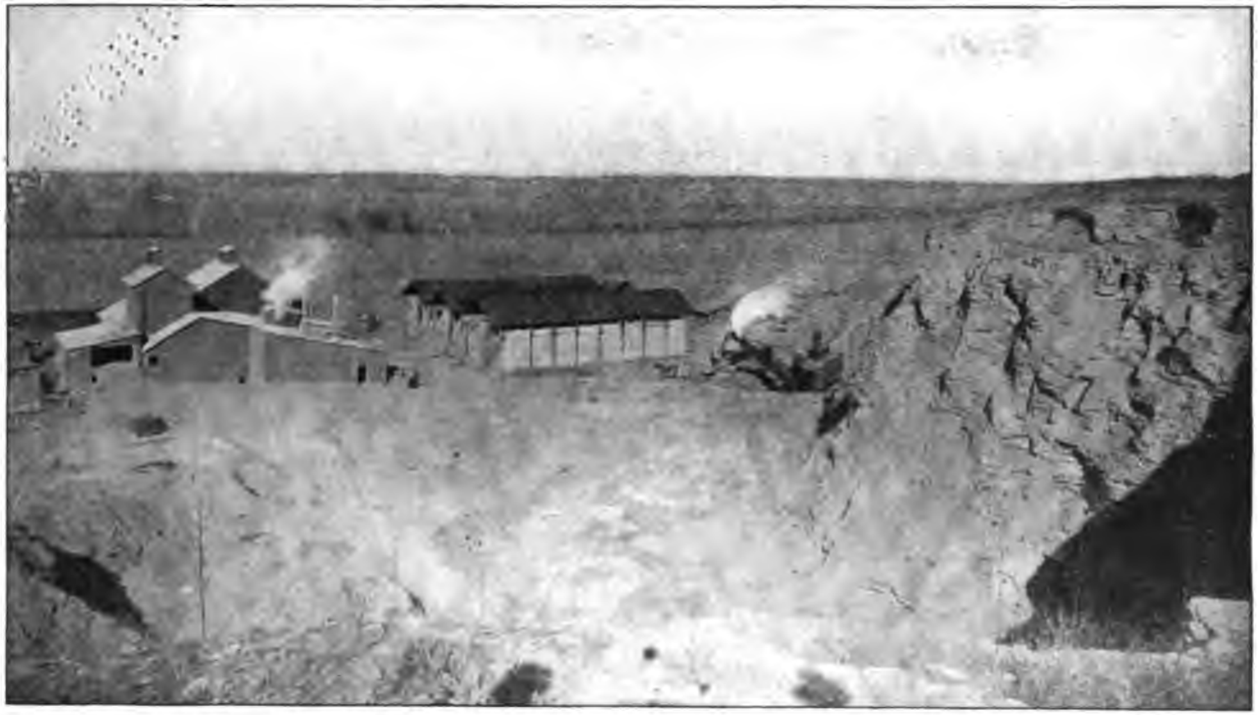
The level of the top of the Mississippian limestone to the bottom of the Coal Measures, as shown by deep borings, is as follows: Atchison, –520; Lawrence, –470; Ottawa, –189; Burlington, –473. This latter record is corroborated by different wells southeast of Burlington, where the limestone surface is known to dip to the west. Thus, at Neosho Falls it is –302, at Neodesha about –275, etc., making the Burlington level as given very probable. The upper surface of the Mississippian, therefore, dips southwest from Ottawa to Burlington almost eight feet to the mile; from Ottawa to Atchison it dips northward about five feet to the mile, which establishes an anticlinal ridge in its upper surface in the vicinity of Ottawa.

The data just given may serve also to determine the thickness of the Coal Measures below the base of the Upper Oread limestone. At Atchison this distance is 1387 feet; at Lawrence, about 1480; at Ottawa, 1230; at Burlington, 1556. A deep well was drilled at Saxton, Mo., during the past summer, by the same company that drilled the Atchison well. Saxton is about six miles southeast of St. Joseph, or about twenty-five miles northeast of Atchison, and has an elevation of 881 feet. The mouth of the well is but a few feet below this point—we will say ten. The bottom of the Coal Measures was reached at 1077, or at 206 below tide. There is, therefore, a rapid rise in the upper surface of the Mississippian northeastward from Atchison equaling 12.5 feet to the mile. On the surface this rise begins about six miles north of the city.

From the above data, it will be seen that there is a marked synclinal trough under Atchison, with the south wall at Ottawa or beyond, and the north wall probably beyond the limits of our detailed knowledge. To the south from Ottawa the upper surface of the Mississippian dips to the southwest much faster than the Oread limestone does, as given above. We must conclude, therefore, that the Atchison syncline and ridges north and south of it owe their existence partly to conditions existing during Coal Measure time, and partly to subsequent earth movements which intensified the irregularities already existing.

The above confirms an idea the writer has had for years, but for which there were not sufficient data to warrant its publication, namely, that during Coal Measure time conditions were favorable for the unusual accumulation of earthy sediments in a submarine valley under portions of northern Kansas, with a corresponding ridge to the south, which is now marked as a gentle anticline, partially determined by earth movements subsequent to Coal Measure time. A comparison of the Atchison limestones below 481 feet with the same limestones to the south shows that here they are much less prominent than in the southern part of the state. A deep well at Topeka, and one still farther west, at McFarland, reveal the same conditions. This was commented upon recently, but without any suggestions as to cause. The physical properties of the sandstones and shales, as is so well brought out by Mr. Morscher in his notes, indicate strongly that this area was a subsiding one during Lower Coal Measure time, and that the accumulation of sand and silt was so great and continuous limestone could scarcely be formed. Such conditions were more favorable for coal formation than those favoring the production of larger amounts of limestone, and probably accounts for the much greater abundance of coal in the vicinity of Leavenworth and Atchison than is found along a line including Paola, Ottawa, Garnett, and Emporia.

The anticlinal ridge above mentioned seems to extend at least half way across the state. It has been noticed as being prominent at many places. Now we have positive knowledge of its existence in the east end of the state, and in the vicinity of



Brick Plant of Coffeyville Vitrified Brick Company, Cherryvale, showing Shale Mound and Steam Shovel.

Hutchinson, as is clearly and positively shown by the geologic section published by Mr. M. Z. Kirk.* This section shows that Hutchinson is immediately over a slight anticline, plainly apparent in the salt beds and the overlying Wellington shales, and that the latter thicken both to the north and south, indicating that the anticline was partly formed during the Wellington shales period. Whether this Hutchinson anticline is connected with the one farther east is yet undetermined, but quite likely it is, as the two correspond in position, direction, and nature.

The character of the sandstone immediately at the contact line with the Mississippian limestone is interesting. It seems to be somewhat of the nature of a conglomerate, although not markedly so. It may also be of great economic importance as a water-carrier, should it continue to drain the overlying water. One of the difficulties feared in connection with mining coal at so great a depth is water, which here seems to be artesian in character. The Coal Measure formations come to the surface to the east of Atchison on higher ground than the mouth of the well. This permits a gentle artesian flow, which, for the well, had a maximum value of 265 cubic inches per minute. Upon striking the coarse sandstone at the base of the Coal Measures the flow entirely ceased, implying that the sandstone in some way serves as a subdrainage. The eastern outcropping of this rock probably is lower than the mouth of the well, so that the water pressure is sufficient to force the water eastward through this lower channel. Should this be correct, the drainage can only be kept up while the pressure is maintained as now produced by the column of water in the well.

The Mississippian limestone at Atchison is wonderfully similar to that found nearly 200 miles away, in southwest Missouri and southeast Kansas. Here and there all through it the well known, interesting and peculiar markings called "crow-foot" by quarrymen may be found. A thin shale or mud parting, variable in direction, cuts the limestone in such a way that the two walls present interlocking surfaces very like sutures in human skull bones or joints of some ammonite shells. The analysis appended to the log shows that in composition the limestone closely resembles the Missouri rock also.

* Min. Res. Kan. 1898, pl. VI.

IV.—OIL AND GAS.

IN the oil and gas region of the state developments during the past two years were moderate, but substantial.

Oil.

The most notable development in oil production during the year was at Chanute. Years ago prospecting was done by the city and by those veteran prospectors, Guffey & Galey, but with such indifferent success that the field was abandoned. Later the city began prospecting, seeking gas principally, and was rewarded by finding it in comparative abundance. In 1899 Mr. I. N. Knapp, of Omaha, attracted by a fair showing of oil in two wells drilled by the city, obtained leases and began drilling. His success was sufficient to allow him to begin shipping oil in June, 1900.

During the latter part of 1901 other companies began operations, so that at the present time, May, 1902, a number of incorporated stock companies are in the field with large leaseholdings and the usual amount of treasury stock for sale. One company reports seventeen wells drilled, all of which are oil-producers; another company has seven or eight, without a failure; and still others are doing well. Thus far the capacity of the new wells has been estimated only, as none of the companies are yet producing oil, Mr. Knapp being the only one who has actually tested wells by producing and marketing the oil.

An area lying in the southeast part of town is locally known as "Gas Ridge," throughout which every well is a producer. To the east, in the river valley, other gas wells have been obtained, and three or four miles to the southwest, on the uplands, what seems to be a distinct gas-field has been developed by three wells, each of which is a good producer.

The oil territory seems to be confined to the river valley east, northeast and north of the city, with present developments reaching to the northwest along the river valley, where for a distance of three or four miles oil is known to exist, but to what extent future developments alone can determine.

Mr. Knapp has drilled fifty-one wells, twenty-eight of which are now producing oil, and three others are ready to be connected with the pipe-lines, three are fair gas wells, leaving seventeen failures. When we remember that he was practically the pioneer prospector, and that his territory was about four miles square, this is considered a fair showing. Since the productive area has been located, the percentage of failures has been much less than the above.

The following is a log of Knapp well No. 8, which may be taken as a fair representative of wells in the river valley. It will be noted that the general geology of this field is practically the same as that of Neodesha, Coffeyville, and Iola.

Record of an Oil Well (No. 8) at Chanute, Kan.

By I. N. KNAPP.

Drilling commenced April 3, 1900; finished to a depth of 748 feet, and closed in April 18. July 25 well was shot with 50 quarts of nitro-glycerine and put to producing. In September, 1900, the well was drilled to gas sand and a gas well developed, showing six pounds water pressure on open end of five-inch casing, equal to a daily yield of about 3,000,000 cubic feet.

Thickness of each formation.		Distance from surface to bottom of formation.
17	Soil	17
6	Gravel	23
87	Limestone	110
5	Shale	115
27	Limestone	142
2	Shale	144
16	Limestone	160
12	Sand	172
93	Shale	265
5	Limestone	270
10	Sand	280
40	Shale	320
15	Limestone	335
44	Shale	379
5	Sand	384

Thickness of each formation.		Distance from surface to bottom of formation.
16	Shale	400
55	Limestone	455
5	Shale (water)	460
14	Shale	474
8	Sand	482
7	Limestone	520
181	Shale	701
21	Sand, making some gas	722
15	Sand, yielding oil	737
41	Black shale	778
6	Sand	784
14	Gas sand	798

Casing used as follows: 23 feet of 8¼ inch; 174 feet of 6¼ inch (which was drawn); 604 feet of 5 inch.

Well produced 208 barrels of oil first month, and 1377 barrels first year; last month of year, 91 barrels.

Handling Oil. Mr. Knapp has installed a plant for pumping and handling oil by compressed air. He has built a central power-house, in which is a Westinghouse gas-engine and an air-compressor, from which compressed air is conducted to all points desired. It is believed this is the second plant in America using compressed air to pump oil, the first being at Corsicana, Tex., and a third being in California.

The power station is a one-story brick building, used both for power-house and office. It shelters a three-cylinder, 11x12 Westinghouse gas-engine of 85-horse-power capacity, and a Rand air compressor, 11"x5"x16", class D, belt driven, which, with 120 revolutions per minute, has a capacity of 210 cubic feet free air per minute raised to a pressure of 350 pounds, requiring from 65 to 70 horse-power to operate it. The excess power of the gas-engine over that required for the air-compressor is used in part to pump oil from the large tank into the oil-cans, and in part for pipe threading and a matter of safety.

The compressed air is conducted through 2-inch pipes all over the oil-field. It is used to blow oil out of the wells, and also to run the pumps for pumping oil from the small local tanks into the larger tank near the power-house. The arrangement at each well is the same, and consists of a small oil tank

8 feet high and 8 feet in diameter, with a capacity of about 70 barrels, connected with the well and pump by a system of pipes. In drilling a well, an 8-inch casing about 25 feet long is used to shut off surface-water. Inside this a 6-inch casing is put down 200 feet or more and afterwards withdrawn. Lastly, a 5-inch casing is put in which goes down 600 feet, and which remains as long as the life of the well continues. At the upper end of the 5-inch casing a 5-inch T is screwed on, from which a 5-inch conduit leads to the tank. Through an opening in the top cap the 2-inch air pipe enters, and passes down to the bottom of the well. When valves are properly opened compressed air escapes at the lower end of the 2-inch pipe and literally blows the oil out through the 5-inch pipe and into the tank. The tank is placed on a little mound of earth about three feet high, partially to guard against damage from flood water, but principally to let gravity feed oil from the tank into the pump near by. A 2-inch pipe is inserted at the bottom of the tank, which leads to a small pump, and ultimately to the large storing tank. The pipe carrying compressed air likewise leads to the same pump, supplying power for running it.

Wells producing but 2 or 3 barrels per day are blown once every 24 hours, while those producing 20 to 30 barrels are blown six times every 24 hours, experience having shown that more frequent blowing does not increase the production. Ordinarily the air pressure used is about 300 pounds, but it frequently runs down to 250 pounds. A Bristol recording pressure gage is used, which automatically produces a continuous record.

The large central tank is fifty feet in diameter and forty feet high, with a capacity of 14,000 barrels. It is situated in the angle between the M. K. & T. and the Santa Fe railways. Near by, on each line, are the loading racks, where five oil cars may be stationed at a time. A 3-inch pipe leads from the large tank to each loading tank, and is so arranged that oil flows directly from the tank into the car. The tracks of the M. K. & T. are on lower ground than the tank, so that loading is done by gravity, but those of the Santa Fe are on higher ground, loading being done by pumping.

The Chanute fields are interesting in a number of ways:

First.—It is now known to a certainty that the oil- and gas-bearing sands are not very uniform, and not continuous over the entire area. A number of instances are known like the following: Three wells, 500 feet apart, are in a straight line. The two extremes are producers, showing a good amount of oil sand; the middle one, only 500 feet from each of the others, is a failure, showing practically no oil sand. In other instances the oil sand is entirely missing, but the lower gas sand is present, yielding large quantities of gas, and in two cases no oil or gas sand was found at all.

Second.—In the Chanute field, the gas-bearing sands uniformly lie below the oil sands, and are separated from them by about forty feet of shale. This is so different from conditions previously observed in other oil and gas regions that it is quite remarkable. Similar conditions have been reported from other Kansas areas, but probably nowhere else in the state are they so well shown. Here, in quite a number of instances, a fair oil producer has been changed into a gas producer by drilling through the forty feet of separating shale.

Third.—The Chanute field was pronounced a failure by the first prospectors, which resulted in the territory lying idle for a number of years. It is so spotted that here and there are barren areas. Unfortunately, the first few wells were in those places. How many other good localities in the state have been similarly abandoned cannot be known at present.

The Prairie Oil and Gas Company, formerly the Forest Oil Company, at Neodesha, increase their number of producing wells for each year by about 20 per cent., with a marked increase of oil production in 1901. The Independence Gas Company likewise has some oil-producing wells, as has also Mr. Reyer, in the southeast corner of Chautauqua county. The largest producer of oil during each of the two years, 1900 and 1901, was the Prairie Oil Company, of Neodesha, but a number of other companies produced a considerable amount, particularly Mr. Knapp, of Chanute. The increase of production in 1901 was princi-

pally due to Mr. Knapp's operations, but the Prairie company also had an increase of over 50 per cent., while a number of lesser companies sent small amounts into the market.

The Standard Oil Company's refinery at Neodesha has been in successful operation the entire time during the last two years. It is a small refinery, handling from 9000 to 11,000 barrels per month. It is supplied from Kansas wells and those near by in the Indian Territory, particularly near Bartlesville.

The company kindly reported the year's transactions to this office. In 1900 they handled a little over 106,000 barrels of crude petroleum. It seems that the products obtained varied slightly, as old wells gave out and new ones come in. In general, however, it may be stated that they obtain about 40 per cent. light oils, 50 per cent. fuel oil, and 10 per cent. unaccounted for.

In 1901 their business was a little greater than the year previous. They handled about 125,000 barrels crude petroleum, which is an increase of nearly 20 per cent. over the business done the year previous.

Table XIII exhibits production of crude petroleum in the state from 1889 to 1901, inclusive, with value of same.

TABLE XIII.

PRODUCTION OF PETROLEUM IN KANSAS FOR 1886 TO 1901, INCLUSIVE.

Figures for 1889 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.*	Barrels.	YEAR.	Barrels.	Price per barrel.	Value.
1889......	500	1894......	40,000	48 cts.	$19,200 00
1890......	1,200	1895......	44,430	64 "	28,435 20
1891......	1,400	1896......	113,571	63 "	71,549 73
1892......	....	1897......	90,000	60 "	54,000 00
1893......	18,000	1898......	†88,000	$2 00	176,000 00
		1899......	85,215	75 cts.	52,167 00
		1900......	91,294	80 "	79,035 20
		1901......	169,197	80 "	135,357 60
		Totals..	721,707	67 cts.	$615,744 73

*Totals include estimated value, $9320, of the product from 1889 to 1893, which was 21,100 barrels.

†Refined oil.

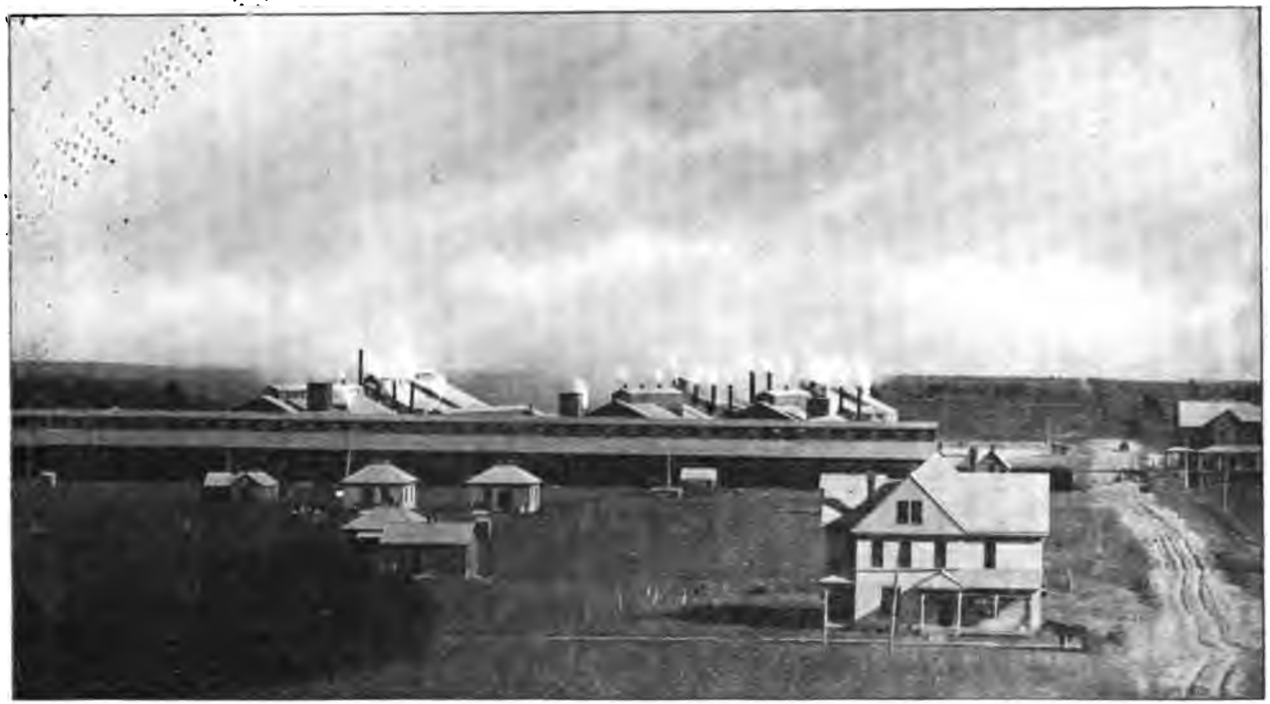
Natural Gas.

The year 1900 witnessed a large increase in the production of natural gas. Many new wells were drilled in the vicinity of Iola, which resulted in extending the gas field further west than previously known, and also in showing that the territory near La Harpe is more productive than previously had been considered. In the vicinity of Chanute surprisingly large amounts of gas were obtained, wells to the east, south and west of the city being productive. Likewise, the continued prospecting at Cherryvale produced some exceedingly strong wells. The Edgar Zinc Company has a number of very satisfactory wells, some of which are being used, while others have been closed in for future use. The Cherryvale Gas Company has carried its prospecting to the east, and has developed some strong wells, with a flowage capacity close to 10,000,000 cubic feet per twenty-four hours. Similarly, developments in the vicinity of Coffeyville have been satisfactory, showing that, instead of a diminution of gas, there is in reality a great increase in available gas, making our fields stronger and better than ever before known.

A remarkably strong gas well was drilled in October, 1901, seven miles northwest of Independence. It had an initial pressure of 425 pounds and a flowage capacity of about 10,000,000 cubic feet per twenty-four hours, according to measurements made by Mr. McBride, of the Independence Gas Company.

About two and one-half miles northwest of Caney, in May, 1901, an unusually strong gas well was drilled, which probably is the strongest well in the state. At the depth of 1480 feet a gas pressure of 660 pounds per square inch was obtained, with a flowage capacity of between 14,000,000 and 15,000,000 feet per twenty-four hours.

As this is the farthest southwest of any notable gas well so far obtained in the state, it becomes all the more interesting. Other gas wells are known farther west, in the southeast part of Chautauqua county, particularly in the vicinity of Peru. The Coal Measures throughout central Montgomery county are from 1100 to 1200 feet thick. The Caney well did not pass



Iola Portland Cement Factory, Autumn of 1901.

through them, so that we do not know their exact thickness at Caney. The drillers, however, by comparing the logs of this well with that of other wells of the vicinity, think that the Mississippian limestone would have been reached within the next 50 feet. The bottom of the last limestone was at 1090 feet, which probably marks the top of the Cherokee shales. This gives us 390 feet in the Cherokee shales. If they are 450 feet thick at Caney, then the Mississippian limestone would have been reached at 1530. The elevation of the mouth of the well is about 730 feet above tide, and the distance from Galena, where the Mississippian outcrops, is almost exactly seventy miles. At Galena the summit of the limestone hills is about 1050 feet above tide. The bottom of the Caney well is 750 feet below tide, and the surface of the Mississippian is probably 50 feet lower down, making a total of 1850 feet for the dip of the upper surface of the Mississippian from Galena to Caney, or a little over 26 feet to the mile. This is quite interesting, as it shows a greater dip than before known in the state.

The consumption of gas during the year was perhaps more than double that of any previous year. It is difficult to make a practical calculation of the value of gas consumed. If we use the total gross income from gas companies of various cities, we find a discrepancy, because prices in different places vary almost 100 per cent. The large smelters and other factories use large amounts, but here it is practically impossible to determine the actual value of gas consumed. If gas were not cheaper than coal the smelters would not exist where they are, and hence the gas would not be used. Yet, if the gas consumed has as much heating capacity as a given quantity of coal, why should it not be given as high a value? These illustrations will serve to show how estimates of the total value of gas consumed, made by different parties, may vary and yet each be approximately correct.

Still another difficulty arises from the fact that in some localities factories own their own gas, and therefore their consumption does not appear on the books of the gas company, while in other cities factories buy their gas directly from the gas com-

panies; so that, in gathering statistics for the total production, it is difficult to avoid including certain industries in certain places and excluding them in others.

During the year 1901 a much larger amount of gas was consumed than during 1900, particularly by the zinc smelters and other manufacturing concerns.

The following may be given as a close approximation for the years 1900 and 1901:

	1900.	1901.
Gas sold by city gas companies or companies having franchises in cities	$207,096	$253,256
Zinc smelting	273,000	372,750
Brick (not included in city reports)	40,000	45,000
Cement factories and other mills not otherwise included	45,000	60,000
Farmhouses and small villages not included above	37,500	37,500
Totals	$602,596	$768,506

The estimate of $37,500 for farmhouses, etc., is based upon the following conditions: Different companies owning leases on farm lands have the leases made in such a way that a certain annual cash payment is to be made, or, if not, a supply of gas is to be given to the farmhouses in order to retain the validity of leases. This has resulted in all the companies having a comparatively large mileage of pipe-lines in rural districts. One company, for example, has seventy-five miles, another seventy miles, etc. Two hundred miles is a low estimate of such pipes delivering gas to farmhouses. Also some small villages consume a small amount of gas which is not included in the above estimate. Adding all these together, the sum total is more likely to exceed the $37,500 than to fall below it.

Table XIV shows the value of natural gas produced in Kansas from 1889 to 1901, inclusive. The large increase during the last three years is due principally to the establishment within the state of manufacturing plants.

TABLE XIV.

SHOWING VALUE OF NATURAL GAS PRODUCED IN KANSAS FROM 1889 TO 1901.

Figures for 1889 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.	Value.	YEAR.	Value.
1889	$15,873	1897	$155,500
1890	12,000	1898	188,840
1891	5,500	1899	257,500
1892	40,795	1900	602,596
1893	50,000	1901	768,506
1894	86,600		
1895	112,400	Total	$2,420,866
1896	124,750		

V.—CLAY PRODUCTS.

DURING the years 1900 and 1901 there was an increased demand for all kinds of brick and other clay goods, due largely to the general commercial activity in the state. There was a greater increase in the production of brick than of any other one commodity, although other kinds of clay products felt the influence of greater commercial prosperity. The great in crease in value of total production for the year 1900 over any previous year is due principally to an increase in number of brick manufactured. It will be noticed that the total value of production for 1900 is more than double that of 1899. The increase of 1901 over 1900 is not so marked, but is sufficient to show a healthy condition of the business.

One item of increase for these years is that of burnt clay for ballast along the Union Pacific railway. During the summer of 1900 this company operated a number of pits along its line burning the black gumbo soil in the river valleys to a clay ballast which is now successfully used throughout more than half the entire length of the main line of that railroad in the state. It will be noticed that for each of these years the value of clay ballast exceeds $100,000. This is reckoning it at fifty-four cents per cubic yard, which is far below the price of crushed stone, although the product is almost as good.

New Plants.

A number of new plants have been constructed during the past two years. At Pittsburg a plant was established during 1901 for the manufacture of sewer tiles. It uses a shale found just southwest of the city limits, and makes an excellent grade of tile. Circular, down-draft kilns were employed and slack coal used for fuel.

At Chanute two brick plants have been established, one the Chanute Vitrified and Clay Manufacturing Company, located about two miles south of the city. This plant began operations in July, 1900. Recently it has been purchased by the Coffeyville Brick Company. A second plant was established during 1901, known as the Kansas Vitrified Brick Company. The plant is located about four miles southwest of town. Each plant is being successfully operated.

At the clay pit southwest of Chanute an interesting series of fissures in the shale is exposed, shown in plates II and III. Plate II shows the almost horizontal bedding planes of the shale, with the fissures near the right-hand end. Plate III shows the same fissures, from another photograph.

A brick plant was established at Neodesha during the summer of 1900. The shale it began using, however, carried too much lime, and brick of an inferior quality was made. This led to moving the plant to the west side of the Verdigris valley, near the little town of Sycamore, on the Missouri Pacific railway line, about six miles north of Independence. The Nesch Brick Company, of Pittsburg, are establishing a large plant at this point, probably being attracted by the strong gas wells recently drilled near that place.

A number of other new brick plants have been erected at different places throughout the eastern fourth of the state, some using coal for fuel and others natural gas.

It is reported that the Dickey Sewer Pipe Company, of Kansas City, has made arrangements to establish a large sewer-pipe plant at Chanute, but no work has yet been done towards the erection of the plant. Table XV exhibits the production of clay products in the state from 1882 to 1901, inclusive. If the production continues to increase, as it probably will, the clay industry will soon be one of the leading industries of the state.

TABLE XV.

SHOWING AMOUNT, KIND AND VALUE OF KANSAS CLAY PRODUCTS FROM 1892 TO 1901, INCLUSIVE.

Figures for 1893 to 1896, inclusive, are taken from the reports of the U. S. Geological Survey.

YEAR.	Common brick.			Dry-pressed brick. *a*			Re-pressed brick.			Vitrified brick.			Other brick, value.	Drain-tile, value.	Other clay products, value.	Total value.
	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.	No. of thousand.	Av. price per M.	Value.				
1892 *b*.....	25,000	$5 75	$142,750	550	$7 50	$4,125	....	....	....	10,600	$8 00	$84,800	....	$6,000	$5,000	$242,675
1893 *c*.....	20,000	5 75	115,000	1,000	7 50	7,500	....	....	....	8,000	8 00	64,000	....	5,000	4,500	196,000
1894 *d*.....	24,518	5 75	141,042	....	....	....	....	....	....	7,948	7 21	57,310	....	8,048	12,175	218,575
1895.......	20,756	5 87	121,892	3,730	6 91	25,275	....	....	....	7,902	7 87	62,190	....	4,090	33,700	247,647
1896.......	19,694	5 59	110,254	1,541	6 13	9,440	....	....	....	16,934	7 39	125,293	....	4,400	10,700	260,087
1897.......	19,548	5 33	104,257	1,948	5 26	10,241	....	....	....	18,378	7 18	132,222	....	7,600	11,000	265,320
1898.......	23,157	6 34	146,765	5,050	5 55	28,050	1,525	$6 72	$10,250	26,182	7 28	190,735	$6,088	8,592	150	390,630
1899.......	25,750	6 25	160,937	6,225	6 00	37,350	3,275	7 25	25,381	26,478	7 25	181,943	....	9,275	844	415,780
1900.......	56,921	5 36	305,209	*f*	*f*	*f*	7,500	7 50	56,250	44,970	7 12	320,105	21,555	10,250	*e* 116,363	829,732
1901.......	69,706	5 55	386,868	*f*	*f*	*f*	11,665	8 00	93,320	41,319	7 52	310,719	23,175	11,126	*e* 102,600	927,808
Totals,	305,050	$5 75	$1,734,974	....	....	....	23,965	$7 37	$185,201	208,711	$7 43	$1,529,317	$50,818	$74,381	$297,032	$3,994,204

a. Previous to 1898 all pressed brick were figured together.
b. Only a partial report is obtainable for 1892.
c. Estimated.
d. For 1894 the common and pressed brick were figured together.
e. Principally for railroad ballast.
f. No report.

VI.—GYPSUM CEMENT PLASTERS.

DURING the years 1900 and 1901 gypsum interests in Kansas witnessed a number of changes. The mill at Mulvane, owned and operated by the American Cement Plaster Company, did a large business in 1900, but closed during 1901. Other changes, mentioned later, likewise took place, so that at the close of 1901 the general conditions of business were very different from what had previously existed.

During the year 1900 there was a considerable falling off of the total production, with a decided decrease in average price. Plaster made from gypsum earth sells higher than that made from rock gypsum at Blue Rapids and Hope. The decrease in production is principally at the mills using gypsum earth. This cuts down the average price by decreasing the output of the higher-priced material.

At Blue Rapids five different kinds of products are marketed, as follows: Wall plaster, white-coat finish, molding and dental plaster, land plaster, and crushed gypsum rock for mixing with Portland cement.

The company operating at Medicine Lodge for some years has declined to report to this office the volume of business done. It is known that it manufactures a superior grade of plaster, used principally in Eastern cities. But how much it makes, and at what price it is sold, could only be approximated by making inquiries of the general dealers. This seems hardly desirable, and therefore the summaries used do not include that plant.

During the year 1901, a number of changes have taken place in the ownership and operation of gypsum mills in Kansas. The mill at Mulvane belonging to the American Cement Plaster Company was closed the last of June. As the company has

large interests at Acme, Tex., the closing of the Mulvane mill did not affect the volume of its business. The mill at Dillon, formerly belonging to the Salina Cement Plaster Company, was closed and torn down. The mill near Solomon, which for a long number of years was in operation, using rock gypsum, was closed more than a year ago.

The Samson Cement Company, of Burns, with Mr. G. Heller as president, was sold to Mr. A. D. Mackey, of Lawrence, and is still being operated under the old company name. The Salina Cement Plaster Company changed management; Messrs. A. and J. A. Henley, of Lawrence, principal owners of the American Cement Plaster Company, and Joab Mulvane, of Topeka, becoming the principal stockholders. A new board of directors was elected in June and the offices of the company moved to Lawrence, the business being done practically under the same management with the American Cement Plaster Company. The mill at Dillon, above referred to, was abandoned before this change, so that the Salina Cement Plaster Company thus reorganized is still operating its mill at Longford. The Great Western Cement Plaster Company, of Blue Rapids, was recently bought outright by members of the American Cement Plaster Company, and the offices moved to Lawrence, although business is still being done at Blue Rapids under the old firm name. The American Cement Plaster Company, both at Longford, Kan., and Acme, Tex., use the gypsum earth (gypse erde), which makes a brown plaster. With such material, it is necessary to use plaster of Paris made from rock gypsum for the third, or white, coat in plastering. The Blue Rapids mill is operated entirely on rock gypsum, so that a white coat material can be supplied from this mill to all customers of the company. In this way the owners of the American Cement Plaster Company have obtained control of the Salina Cement Plaster Company and the Great Western Cement Plaster Company, and transact the business for the three companies from one office in Lawrence.

During the latter half of the year a new company was organized, known as the Ætna Cement Plaster Company. It seems

End View of a 300-horse-power Westinghouse Gas-engine Used in Iola Portland Cement Factory.

to be a reorganization of the old Aluminite Company. They have obtained possession of the grounds and mill of the old Aluminite Company, about two and a half miles south of Dillon, and have remodeled the mill, changing it to a four-kettle capacity, and are now in the market with manufactured plaster.

The Roman Cement Plaster Company, with offices in Kansas City and mills at Springvale, Kan., have been in operation irregularly throughout the year. The mills at Hope, Kan., likewise have been in operation, but the name of the company has been changed to that of the Wymore Cement Plaster Company, with offices at Wymore, Neb. This was brought about by a Wymore company of jobbers in cements and plasters purchasing the plant.

At the close of the year 1901, therefore, the following companies were doing business in Kansas:

NAME OF COMPANY.	LOCATION OF OFFICE.	LOCATION OF MILLS.
American Cement Plaster Co.......	Lawrence, Kan.	Acme, Tex.
Salina Cement Plaster Co..........	" "	Longford, Kan.
Great Western Cement Plaster Co..	" "	Blue Rapids, Kan.
Blue Rapids Cement Plaster Co....	Blue Rapids, Kan.	" " "
Blue Valley Cement Plaster Co.....	" " "	" " "
Wymore Cement Plaster Co........	Wymore, Neb.	Hope, Kan.
Ætna Cement Plaster Co	Kansas City, Mo.	Dillon, Kan.
Samson Cement Plaster Co	Burns, Kan.	Burns, Kan.
Roman Cement Plaster Co.........	Kansas City, Mo.	Springvale, Kan.

Table XVI exhibits the total production of gypsum products for Kansas and value of same from 1889 to 1901, inclusive.

TABLE XVI.

SHOWING AMOUNT AND VALUE OF GYPSUM PRODUCED IN KANSAS FROM 1889 TO 1901,* inclusive.

YEAR.	Output in tons (2000 pounds).	Average price per ton.	Value of output.
1889	17,332	$5 44	$94,235
1890	20,250	3 58	72,457
1891	40,217	4 01	161,322
1892	41,016	4 76	195,197
1893	43,631	4 16	181,599
1894	64,889	4 65	301,884
1895	72,947	3 74	272,531
1896	49,435	3 00	148,371
1897	50,045	5 05	252,811
1898	39,776	3 26	129,652
1899	61,103	4 30	262,743
1900	56,112	4 35	244,611
1901	49,217	4 25	209,172
Totals	605,970	$4 20	$2,526,585

* Figures from 1889 to 1896, inclusive, are taken from the reports of the United States Geological Survey.

VII.—HYDRAULIC AND PORTLAND CEMENT.

THE only manufacturers of hydraulic cement in the state are the two at Fort Scott, reports for which have appeared at different times in the earlier Reports of this Survey. They are the Kansas City & Fort Scott Cement Company, with offices in Kansas City, and the Fort Scott Hydraulic Cement Company. Their annual output is fairly constant, ranging from 125,000 to 160,000 barrels per year. The price of the commodity likewise is almost constant, being about forty cents per barrel at the factories. Since the Iola Portland cement factory began operation, the tendency in the West is to use Portland cement in many industries which previously had used Fort Scott or Louisville hydraulic cement. This has cut down the production of the Fort Scott factories.

Table XVII exhibits production of hydraulic cement in the state for the years 1900 and 1901, and also the total production since 1888.

Portland Cement.

The large Portland cement factory mentioned in our 1899 report was completed and began operations during the early summer of 1900. The plant is situated just south of the city of Iola, and rests directly on the Iola limestone, which material, when properly mixed with shale from the overlying beds, constitutes the material from which cement is made.

Plate VI is a reproduction of a photograph of the plant, taken during the autumn of 1901. It does not very well represent the general outside appearance of the plant, although it may serve to assist the reader in following a verbal description. The plant consists at present of three individual parts, each of which might be spoken of as a plant by itself, as each is a

duplicate of the others. During the year 1902 large improvements are contemplated, which will greatly increase the present capacity. This enlargement, it is understood, will consist of a reduplication of the individual plants shown in the plate. A view was taken with a camera pointing a little north of east, so that the western side of the buildings is exhibited. The long, narrow building in front is the storeroom, having a capacity sufficient to store several months' production. Beyond the storeroom, beginning on the left, is section 1, a long, narrow structure, trending east and west. Next to the right, with the roof barely showing above the storeroom, is a building used for shop and workroom, for repairs, etc., the one building serving the entire plant. Still further to the right is section 2, and just south of it section 3. Across the driveway to the right stands the two-story frame building used for offices.

Let us begin at the east end of section 1. Here we find a Gates crusher of the largest size, set so that the mouth is on a level with the earth floor. The limestone and shale are hauled into the building and dumped on the floor beside the crusher, into which they are easily shoveled. The two materials are put in together in about the proper proportions for cement-making. From the crusher the material is carried by machinery to the pulverizing station, a little to the west in the building, where it is ground to a fine powder. From here it is carried to a large steel tank, a number of which are placed in a north and south row reaching entirely across the plant. In these tanks the material is mixed with the proper amount of water and thoroughly agitated, giving it a consistency about like thick, rich cream, after which it is called "slurry." A large pipe passes in front of the line of slurry tanks with which each tank is connected. This makes it possible to draw slurry from any one of the tanks or from any number of them at a time.

After a slurry tank is almost filled, and the material thoroughly agitated, a sample of it is withdrawn for analysis, and a proper amount of limestone or shale is added to bring the slurry to the right chemical composition. While the tank in

question is being filled and adjusted, slurry from other tanks is drawn out for use.

Immediately west of the slurry tanks are located the "rotaries," or revolving furnaces. A rotary is a long, slender, steel tube, resembling, in general appearance, a steel water-tower lying on its side. Those at Iola are seventy-two feet long, and have a diameter in the clear of six feet inside, and have a fire-brick lining of about twelve inches thick, which would give the steel cylinder a diameter of about eight feet. Each cylinder is mounted on bearings, so that the west end is slightly lower than the east. When the furnace is in blast it is given a slow rotary motion, by means of cog-gearing working on the outside of the furnace.

A short slurry pipe, passing through at right angles to the long pipe already mentioned, carries slurry into the eastern or higher end of the rotary. This liquid material runs into the upper end of the rotary, soon has all of the water driven off, and by the time it has reached the lower end, seventy-two feet away, is completely fused. The flow of slurry is regulated so that the fused mass at the lower end of the rotary forms itself into globules or little balls about an inch in diameter, which roll out onto the floor at the west end, from which place they are elevated while still hot and carried to the pulverizers still farther west.

The fuel, which is natural gas, is driven into the lower or western end of the rotary, and the immense blaze reaches almost entirely through the furnace. The greatest heat in the furnace is near the lower end. In this way, as the slurry enters the upper end and flows down to the lower, it is gradually brought to an increasing temperature, until fusion is effected at the lower end.

After fusion into little balls the material is called "clinker." It is carried westward in the factory and delivered to a Griffith pulverizer, which machine pulverizes it almost to an impalpable powder. From here it is carried across the open space to the wareroom, where it is put into bags for shipment.

The machinery of the plant is operated by a Westinghouse

gas-engine. Plate VII is made from a photograph representing an end view of a 300-horse-power engine. The entire plant is lighted by electricity generated in the plant.

The limestone used is the Iola limestone, so frequently referred to in reports of this Survey. Here at the plant it lies immediately at the surface, so that operations had to begin by working a pit downward into the limestone, which is almost a solid mass forty feet in thickness. Plate VIII is made from a photograph showing masses of the limestone blasted out ready for using. A short distance west of the plant stands a large, almost circular mound capped by a thin limestone, which overlies a shale bed forty or fifty feet in thickness. This supplies shale for the cement. It is carted to the plant by horse power and mixed in with the limestone, as already mentioned, before passing through the Gates crusher. Experience has shown about what proportion of the limestone and shale is desired, so that they are delivered to the crusher in about this ratio.

It is now generally understood that the Portland cement made at Iola compares very favorably with that made elsewhere in America and that imported from England and Germany. It is used very extensively by all Western railroad engineers and Western architects for constructing purposes, and has already established a market throughout almost all the great West, and shipments are reported to have been made to points as far away as South America.

TABLE XVII.

SHOWING AMOUNT AND VALUE OF HYDRAULIC CEMENT PRODUCED IN KANSAS FROM 1888 TO 1901, INCLUSIVE.

The figures from 1888 to 1896, inclusive, are based upon the reports given by the U. S. Geological Survey.

YEAR.	Barrels.	Price per barrel.	Value of output.
1888	40,000	75 cts.	$30,000
1889	150,000	70 "	105,000
1890	150,000	70 "	105,000
1891	140,000	69 "	97,400
1892 *	110,000	69 "	77,000
1893	60,000	35 "	21,000
1894	50,000	50 "	25,000
1895	140,000	40 "	56,000
1896	125,567	40 "	50,226
1897	160,000	40 "	64,000
1898	160,000	38 "	60,800
1899	140,000	45 "	63,000
1900	127,339	40 "	50,333
1901	131.372	43 "	56,490
Totals	1,684,278	52 cts.	$891,289

* Includes Kansas City, Mo,

VIII.—BUILDING AND OTHER STONE.

THE past biennium has been a prosperous period for the stone industry, which is largely due to the great improvement of road-beds made by the different railroad companies. New culverts have been put in, which have required a large amount of dimension stone, and an unusually large quantity of broken rock has been used for ballast. Rough stone for riprapping has also been in great demand. The various towns and cities of eastern Kansas have used large quantities of flagging stone for building walks, and, likewise, an unusually large amount of stone for curbing, where streets have been paved with brick. The general prosperity of the country has also resulted in more large buildings being constructed than usual, which has consumed the best quality of dimension stone, and thousands of small buildings have used ordinary stone for foundations.

In the central part of the state stone fence-posts are used to a great extent. Never before in our history have so many fences been built using stone fence-posts. A strip of country about twenty miles wide, reaching from the north side of the state to the Arkansas river, passing through Osborne, Russell and Rush counties, is the great fence-post area. A limestone belonging to the Benton formation of the Cretaceous is the stone used. It is easily split into long prismatic posts, and is soft enough so that notches are cut at the edges or holes drilled through the posts. The posts are quarried and hauled to the fence lines, sometimes being transported from twelve to fifteen miles. They are set in the ground the same as wooden fence-posts, but usually about thirty to thirty-three feet apart, making from 160 to 175 per mile. Their market value is about twenty-five cents each, delivered at the fence line, and when once in place make a permanent post, which will probably last for hundreds of

Rock Quarry, Iola Portland Cement Plant.

years. It is difficult, in fact impossible, to gather accurate statistics regarding the value of such posts for the past two years. Any one familiar with the country, however, can see such a great change in the amount of fencing used, that he would readily admit many thousand dollars' worth of stone have been used in this way each year.

Almost all of the stone used in Kansas is limestone. The famous Cottonwood limestone still ranks far ahead of any other in production. A line of quarries reaching two-thirds of the way across the state, from the north side southward to beyond the Cottonwood river, represents exposures of this limestone. Quite likely more than half of the total production of the dimension stone of the state comes from this limestone. The largest individual item in value specified by use is broken stone used for ballast. This, of course, may be obtained from any limestone ledge conveniently located. But first-class dimension stone outside of the Cottonwood stone horizon is not extensively produced, excepting from the softer, less desirable, Permian limestone.

Table XVIII exhibits the total stone production of the state from 1880 to 1901, inclusive.

TABLE XVIII.

SHOWING VALUE OF BUILDING STONE PRODUCED IN KANSAS FROM 1888 TO 1901.

Figures for 1880 to 1896, inclusive, are taken from the reports of the United States Geological Survey.

YEAR.	Sandstone.	Limestone.	Grand totals.
1880	$11,000	$131,570	$142,570
1888*	1,000	144,000	145,570
1889	149,289	478,822	628,111
1890	149,289	478,822	628,111
1891	80,000	300,000	380,000
1892	70,000	310,000	380,000
1893	24,761	175,173	199,934
1894	30,265	241,039	271,304
1895	93,394	316,688	410,082
1896	18,804	158,112	176,916
1897	23,180	173,000	196,180
1898	25,000	180,000	205,000
1899	23,500	550,000	573,500
1900	31,750	455,866	487,616
1901	33,275	495,872	529,157
Totals	$764,507	$4,588,964	$5,354,051

* Reports for 1888 include only (for sandstone) the production from Ritchie; and (for limestone) the production from Winfield, Florence, Augusta, and Oketo.

IX.—SALT.

THE salt industry passed through a number of rather interesting variations in 1900 and 1901. During the second half of 1900 prices advanced very unusually, reaching as high as eighty-five cents per barrel. Such unusually high prices induced other companies to begin the manufacture of salt, which was followed by a fall in the price, and that in turn by a curtailment of output for 1901. The old mines at Kingman were reopened and successfully operated during 1901.

A new company erected a salt plant and began operations at Anthony the same year.

At Hutchinson two salt companies were organized, the Hutchinson Salt Company and the Carey Salt Company. These two plants began operation about the middle of the year 1901. The Pure Salt Company uses the old-fashioned pans, which admit the flame to come in contact with the bottom of the pan and evaporate the brine by direct application of heat.

The Carey Salt Company built a plant new in some respects. The plant consists of three pans, with a daily capacity of 100 barrels each. The pans are made of Iola cement, and are heated by steam-pipes. A floor or bed of cinders was first constructed, on which the cement pans were built. Each pan is 136 feet long, 14 feet wide, and a little over 2 feet high. The heating plant for each pan consists of ten strings of two-and-one-half-inch steam-pipes, lying lengthwise of the pan. Fresh brine is admitted from a pipe at the rear end of the pan and is controlled in quantity of flow by a valve, so that the level of the brine remains the same in the pan at all times. Salt is raked out at the front end and dropped into a long, narrow trough passing in front of all the pans, from which trough it is raked to an elevator and conveyed to cars running on a railway-

track, and finally delivered by the cars to the storeroom. The packing-room is 165 feet long, 52 feet wide, and 14 feet high, and will hold 20,000 barrels of salt.

The use of Portland cement for the manufacture of evaporating pans is new, and will be watched with considerable interest. If the brine has no chemical action on it with continued use, and if the walls do not check, so as to cause leaks, it may prove to be a valuable innovation. It will avoid all iron-rust stains from the pans, which in some instances are troublesome. It may be more economical in fuel than other pans, as the cement pans are such poor conductors of heat. The experiment will be watched with interest.

The Carey salt plant is operated in connection with an ice plant. Fresh steam from the boilers is first used at the ice plant in propelling large engines, and the exhaust steam from the engines is conducted through pipes into the salt plant. It is claimed by the operators that this is also a great saving of fuel. Table XIX exhibits the output and value of salt in Kansas from 1888 to 1901, inclusive.

TABLE XIX.

SHOWING AMOUNT AND VALUE OF KANSAS SALT PRODUCTION FROM 1888 TO 1901, INCLUSIVE.

Statistics for 1888 to 1901, inclusive, from United States Geological Survey reports.

YEAR.	Barrels.	Average price.	Value.
1888	155,000	$1.219	$189,000 00
1889	450,000	.45	202,500 00
1890	882,666	.45	397,199 00
1891	855,536	.357	304,775 00
1892	1,480,100	.523	773,989 00
1893	1,277,180	.369	471,543 00
1894	1,382,409	.383	529,392 00
1895	1,341,617	.36	483,701 00
1896	1,347,793	.31	519,475 00
1897	1,224,980	.34	417,626 94
1898	1,810,809	.27	489,454 23
1899*	2,172,000	.35	760,200 00
1900	1,679,956	.65	1,091,971 40
1901	1,271,015	.60	762,609 00
Totals	17,331,061	$0.474	$7,393,435 57

*Cooperage in 1899 is reported at about twenty-six cents a barrel, and in other years at proportional rates, which should be added to above totals to give a correct idea of the magnitude of the salt industry.

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